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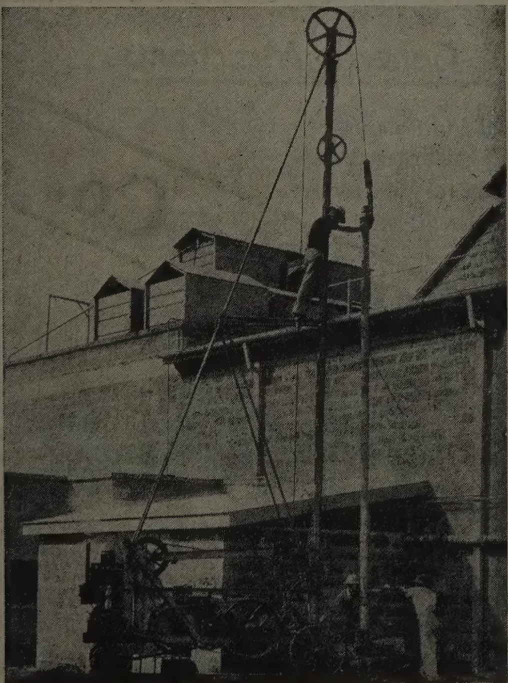

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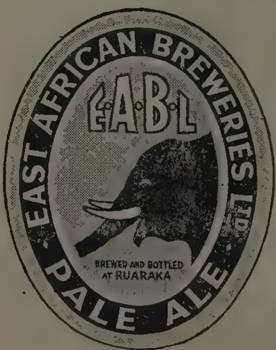

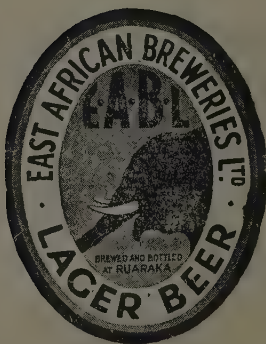

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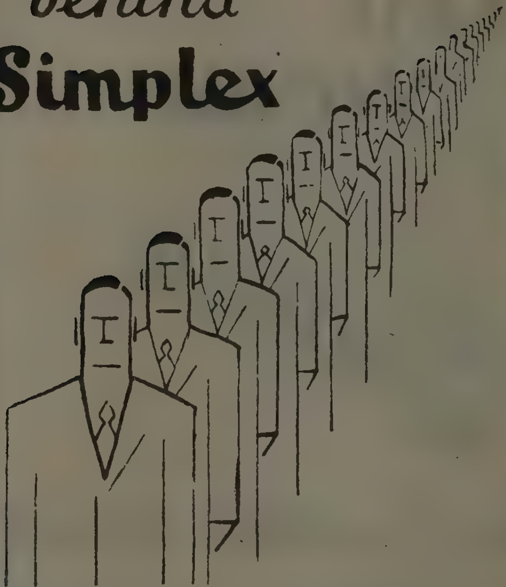

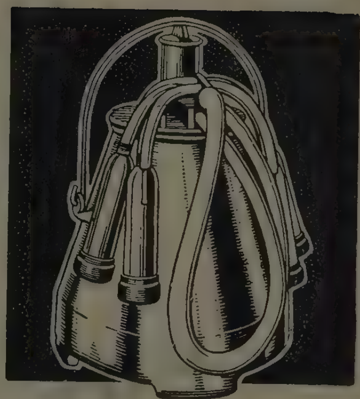

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AGRICULTURAL DEVELOPMENT

His Excellency the Governor of Kenya, Sir Philip Mitchell, recently addressed the Rotary Club, Nairobi, on "the justification—or, as some would call it, the moral basis, of the type of Colony which has been established here in East Africa". The broad views of an administrator of long experience are certain to be of interest to those who have a narrower view of matters of policy, but the theme of this particular speech—"an explanation of the reasons for our being here, the objectives which we are pursuing and the methods for attaining them"—arouses even greater interest than usual at a time when the pace of Colonial development is being increased.

If we look for the moral basis of agricultural development, the historical background given by Sir Philip Mitchell is enlightening. He said: "Here in East Africa we are in fact the northern extremity of a settlement colonization which began at the Cape three centuries ago, apparently contemporaneously, quite accidentally contemporaneously, with a mass migration, or at any rate general movement, of native Africans within the Continent. The aboriginal inhabitants were almost certainly bushmen or pygmies, and they were overrun within the last three centuries by migrations of other African tribes, mainly Bantu and Hamitic, and practically exterminated, unless, of course—and this is possible—they were never more than a very small sprinkling of semi-wild people . . . Although, then these African tribes had had several centuries during which they were free to establish, if they were able, a stable form of society and a government or series of governments, in which agricultural, technical, commercial and economic development could be carried on, and the latent riches of the Continent be made available for a world which needs them with ever-increasing urgency, they proved unable to do anything of the kind; indeed, the available evidence suggests that they were losing ground in the face of the great natural difficulties of their environment . . .".

The lack of success of these African immigrants is strikingly brought out in another remark in this speech: "Just reflect for a moment that no plough had ever entered East African soil until 1890, no wheel had ever turned on road or track". This provides a firm moral foundation for agricultural research in all its forms, but it also shows that for many years we shall be sadly lacking in the fundamental scientific knowledge which is the basis of practical developments. Applied research must be intensified and accelerated in order to keep pace with immediate requirements, but efforts must also be made to strengthen the academic foundations unless we are to be left with a large number of unexplained observations.

The groundnut scheme provides a striking contrast to Sir Philip Mitchell's historical picture. Less than 60 years after the introduction of plough and wheel, a scheme has been started in Tanganyika to apply the latest scientific and technical methods to agricultural production on a scale far larger than has yet been attempted by any single organization. In the most civilized country this would be a big undertaking; in East Africa it is a daring adventure. It can be justified politically by the fact that drastic measures are necessary to fill the gap in the world supply of edible fats, and this urgent need might be considered sufficient to soothe any moral qualms. Fortunately, the groundnut scheme has a moral basis which would justify its existence without the economic necessity for it. It is an experiment in the utilization of large areas of land which have proved to be unsuitable for settlement under the tribal system; those vast stretches of East Africa which the native population have lost in their battle against nature. Soils of low natural fertility, and the lack of easily available domestic water, prevented the intensive settlement which is necessary for protection against tsetse fly. So long as the axe and the hoe were the only weapons of attack, and shifting cultivation the only strategy, these areas could never be reclaimed economically, but a large-scale attack with bulldozers and agricultural machinery, on a scientific plan which is under continuous revision by a research team, seems to offer the best hope of success. If the groundnut scheme is successful, the productive power of every African employed in it will be unbelievably greater than under his present agricultural methods, and he will be able to enjoy a much higher standard of living than he could attain by peasant farming.

But the groundnut scheme is off the main track of British colonial policy. However necessary it may be to-day to produce edible fats quickly and efficiently, and however desirable it may be that Africans should become efficient producers by working in a highly organized agricultural scheme, the change from tribal rule to management by a board of directors is too extreme to be safe. It may be that in time the African will move on his own accord, as we did in Britain, from the feudal system to a socialist government, but that change must be very gradual, and must be directed, in Sir Philip Mitchell's words, "as British colonial policy has been for centuries, to the achievement not of any particular political system but of a state of society in which the men and women of whom it is composed—or at least a large part of them—have reached a stage of spiritual, moral, social, cultural and economic development capable of supporting and operating such democratic forms of government as may then appear desirable to them".

While it is conceivable that the groundnut scheme may prove to be a brilliant short-cut towards self-government in East Africa, it is preferable to look at it now as an experiment in agricultural production, which, we hope, will greatly assist the inhabitants of other parts of the world in their search for better food. Meanwhile we must look for ways in which the African peasant can raise the producing power of his soil, for he, too, is in dire need of food. On a good soil under a well-distributed rainfall his axe and his hoe have caused alarming increases in population, and in some areas pressure on the land has reached a stage where the feeding of the people by the people is a matter for grave anxiety. The problem is whether we can adapt scientific methods of agricultural production to African peasant economy; whether we can break the vicious economic circle in which a man cannot improve his soil because he cannot grow enough on it to pay for the capital outlay which is required for greater production. But the economist cannot start work on this problem until the scientist has found the best method of increasing the productiveness of different types of soil. Accordingly, a small team of field and laboratory workers, a unit of the new East African Agricultural and Forestry Research Organization, have started a comprehensive series of experiments on the use of nitrogen, phosphate, potash and lime in the production of native food crops, and on the value of grass fallow and organic manures in a system which includes chemical fertilizers.

This fertilizer experiments scheme is less spectacular than the groundnut scheme but it is of equal importance to the welfare of the African agriculturalist. The present methods of native agriculture cannot cope with the demands for food by a population which is increasing in numbers, and this difficulty is aggravated by the determination of the British Government that the standard of living of Colonial peoples must be raised as rapidly as possible. Hospitals, schools and welfare centres will create a desire for a better standard of living, but this standard depends on the efficiency of land utilization. It is significant, therefore, that the 1947 report on the Ten-year Development and Welfare Plan for Tanganyika lays stress on the advice from the Secretary of State for the Colonies that urgent steps should be taken to increase the individual productivity of the peasant farmer, in view of the fact that, for many years to come, the economy of the country will be based primarily on agriculture. There is some danger that this urgency may lead to the hope that the results of a few field experiments will show how the productivity of native lands can be raised, but, although indications may appear almost at once these will have to be applied with the greatest caution. Alarmists who are horrified at the thought of the African laying waste his country with the help of chemical fertilizers may rest assured that the officers responsible for this scheme are awake to this danger, but they must balance this with the realization that the native population of East Africa faces acute food shortages, possibly starvation, unless drastic improvements are made in the methods of producing food.

Some moralists may think that we are pushing development too hard, and may even wonder if it would not have been better to leave the African in his picturesque poverty and carefree indifference to progress. Some 60 years ago we had the choice of two alternatives—either to improve the life of the African by every possible means, or to leave him severely alone with his tribal wars, high infant mortality, endemic diseases, and occasional famine. We have chosen the policy of improvement, and having started on it we are committed to carrying it out to the full. If we feed the African when his crops fail, cure him when he is sick, and teach him to read and write, we must also raise his standard of production, or else his society will be based on a false economy which may lead to disaster.

D. W. D.

THE GROUNDNUT SCHEME*

By A. J. Wakefield, C.M.G., B.Sc.

In Britain we have neither sufficient land nor man power to feed ourselves. No longer can we obtain from North America the greater part of the food we have to import. Apart from the question of dollars, Britain must find it difficult to take an independent line in world politics so long as she is dependent on any major power for the means of subsistence.

The shortage of fat is probably the most serious and intractable part of the food position in Britain. The authorities at the Ministry of Food can see no solution to it, in this generation at least, unless some great new source of production is developed. The present world shortage amounts—on the basis of prewar figures, and taking no account of the increase in population and the demands of masses of population in Asia and Africa for better food—to about 2,000,000 tons of fat; this is equivalent to some 5,000,000 tons of groundnuts or more of other oilseeds.

The fat deficiency became a matter of political concern when the British housewife was up in arms early last year against a cut of half ounce of fat a week. Nothing can do more to stabilize Government and the country than the provision of a more adequate diet. No doubt this explains the urgency with which the groundnut project has been undertaken, and the tremendous motive power that is behind it.

The history of the project is this. When Mr. Samuel, Managing Director of the United Africa Company, an associate of the Lever Group who have extensive palm-oil plantation and trading interests in West and Central Africa, was in Tanganyika early in 1946 he considered the possibility of a small development, if the Company could get some suitable land, for the mechanical cultivation of groundnuts.

On his return home he was immediately faced with the realization of the critical long-term situation in oils and fats, which could, it was apparent, only be rectified by rapid and large increase of annual seed crops. Mr. Samuel therefore abandoned the idea of the small development by the Company, and proposed a very large scale development by Government. Accordingly he prepared a brief paper which was submitted to Sir Ben Smith, who was immediately interested in the possibilities.

His proposals for mechanization came out of the obvious fact that it would be useless to expect the 60,000,000 people of tropical Africa to replace the efforts of 360,000,000 Indians. In any case, it is now accepted that the hand-hoe and primitive methods of subsistence agriculture which had prevailed in Africa since Biblical times cannot give more than a miserable existence to the African tribes alone and are, in fact, doomed.

The scheme was immediately blessed by the Cabinet, and a Mission, of which I was a member, was sent out to East Africa on 20th June, 1946. The R.A.F. placed a plane at our disposal, and we covered some 30,000 miles in Tanganyika, Northern Rhodesia and Kenya. The local Departments of Agriculture had already done much spade work for us, and took us to areas of suitable terrain for tractors, where the soil and climate were known to be suitable for groundnuts. Consequently, our mission was completed in ten weeks, and we returned to England on 3rd September.

We considered that the Samuel scheme was practicable and, if it was dealt with as a Mulberry operation of war, that it could be implemented. Our report was submitted to Government on 23rd September, just a year ago. The Cabinet approved it in principle before the end of October. A special section of the Ministry of Food was immediately set up which vetted the scheme throughout November and December—consulting numerous authorities on the major technical, financial and sociological points involved. They concluded that the scheme was soundly based, and that the food needs of Britain demanded its immediate application.

Neither the tremendous difficulties nor the risks involved were overlooked. It was accepted that here and there mistakes would be made. There was no doubt, however, that, given a good scientific service, many of the technical problems could be anticipated and ultimately all should be overcome. Urgency was the keynote; the usual series of experiment and pilot project could not be awaited. It had to be all or nothing. So the Cabinet approved the whole scheme before the end of the year,

* Text of a paper given to the First Conference of the British Society of Soil Science, Oxford, 29th September, 1947.

which was estimated to cost approximately £23,000,000, involving the construction of a new port and railway at an additional cost of £2,250,000.

Government decided that the project should be operated by a Public Corporation, financed entirely by the British Treasury. To this end the Overseas Food Corporation will shortly be established by Statute. Mr. L. A. Plummer is to be the Chairman. Members of the Board include a scientist, Lord Rothschild; and I have also been invited to serve—I suppose because of my experience of tropical agriculture and local conditions. Provision has been made by H.M. Government for the undertaking to be transferred to the local governments when desirable as a step towards the long-term aim of bringing African people in on a co-operative basis.

The urgency was so great that the project could not even await the enactment of the necessary legislation to establish the Corporation. The United Africa Company was therefore invited to become managing agents to the Minister of Food in order that operations might start forthwith, and in December last the Company agreed to undertake this great responsibility. I have been working with them as Technical Adviser, and I am glad to have this opportunity of expressing my admiration and respect for the manner in which they are doing the job under the direction and drive of Mr. W. A. Faure. They are taking no remuneration for it; indeed the cost to them can hardly be calculated. It is not only the United Africa Company, but the whole weight of the world-wide Unilever organization which the Chairman, Mr. Geoffrey Heyworth, has put to the service of the scheme. Without this, and the business experience which Unilevers have brought to bear, I cannot imagine how the tremendous difficulties of supplies could have been overcome.

The managing agency have drawn upon the personnel of their plantations in Africa for the groundnut scheme. They sent out an advance party in January, and have now 175 Europeans on the job in Tanganyika, and the same number engaged by their contractors for bush clearing and erection of installations; 4,700 Africans have been engaged. Up to 100 tractors with bulldozers have been at work for three months, and several thousand acres have been cleared—at the moment we are being held up by the rooting problem, as we are unable to get the implements required for that job. A branch railway has already been built by the Tanganyika Government. Surveys for the new port and railway to serve the main area of 1,750,000 acres in the Southern Province have been completed; construction will proceed almost immediately. All this has been done in less than a year of my handing the Mission's report to the Secretary of State for the Colonies.

There have been other developments of great importance both to Britain and Africa. The groundnut scheme has been extended into the Overseas Food Corporation with a capital of £50,000,000—which can undertake projects for food production almost anywhere overseas. This was quickly followed by the formation of the Colonial Development Corporation. And now we have Mr. Bevin, Sir Stafford Cripps and others pointing to Empire development as the road for Britain's recovery and political independence. I am convinced that Africa holds the key to a solution of the present crisis. It is therefore imperative that the groundnut project succeed. I am sure that there are members of this Society of Soil Science who have much to contribute to these plans, and it is for that reason that I am taking up so much of your time in giving you the picture.

But as important as the project is to Britain, what is more satisfactory to my mind is that our present needs provide the opportunity of placing the African Colonies on their feet. Unless an economic foundation is laid under the ten-year plans for Colonial development and welfare, I am afraid that the latter will be a positive danger. We must also show that, in producing food for export overseas, the natural resources of Africa can be developed rationally and soil fertility even improved and not ruined in the process.

Until the Samuel Scheme was evolved, it seemed to me that East Africa was on the verge of complete economic and social breakdown; even now it is only the production of the European farms in Kenya that is staving off famine. The East African native population are not in a position to make any substantial contribution to world food supplies. They are to be found mostly where water supplies—lakes, rivers and a shallow water table—are present. Soils are impoverished by the primitive methods of peasant agriculture. Erosion and land ruination is inevitable as such penned-in populations increase. The position is made worse as the incidence of disease and the death rate is lessened by the Health Services. Political unrest develops as education proceeds without improvement in the standards of living.

In Tanganyika, for example, we have one-and-a-half million people in the Lake Province, which, until 1940, produced appreciable quantities of cotton, groundnuts and cereals for export overseas. Now they can barely feed themselves and the Tanganyika Government are embarking on a resettlement scheme costing three-quarter million sterling; in my opinion this touches only the fringe of the problem. Again, in Kenya, the Kavirondo Province was previously a great maize-growing area; the soil is now beggared-out. Also an appreciable part of the Ukamba Reserve in Kenya is already ruinate. All told, the East African Governments are faced with the problem of the resettlement of more than a million people. They must also set about the rehabilitation of a million acres and more of impoverished and ruinate land. But resettlement on an individual basis is likely to result in a repetition of the process of land ruination. Let us be frank and face up to the fact that East Africa is approaching a condition of chronic famine.

Mixed farming on the basis of animal husbandry has been held, by myself among others, to be the cure of the ills of African peasant agriculture. Only three or four years ago did it dawn on me that, so long as the cow had to depend for its food on the produce from the land on which it is kept, its manure could not add to the fertility of that land. Animals are, of course, a good medium for getting the farmer to return all crop residues to the land. But that is not enough if the productivity of heavily populated land is to be increased to feed the people and to provide a surplus for sale off the farm. It seems to me that the selling or consuming of meat and milk off the farm, without bringing on to it at least an equivalent amount of plant and animal nutrient, in the form of fertilizers or feeding stuffs from outside the farm, must finally impoverish the soil. The end can be but little different from that of continuous cropping with maize, or one could add even with such leguminous crops as groundnuts and pulses.

It is said that one of the principal aims of Colonial Departments of Agriculture is to determine a rotation of crops which will not only maintain but will also improve soil fertility. I would ask if this is at all possible in itself? Can we merely ring the changes, and export from the farm or consume locally a succession of different crops, whether legumes or not, without replenishing the soil? In one Colony, in a densely-populated maize-producing province, maize is regarded as a soil-destroying crop, and an alternative food crop is being sought which will not have this effect. Can they ever find a crop which will provide a satisfactory number of calories per acre without puttting back the minerals which are removed by the crop? I do not, of course, under-emphasize the role of humus, or the great importance of soil structure. As for the latter point, however, a crumb structure cannot be produced with the light soils of a great part of Tanganyika.

In addition to the so far insoluble problem of soil impoverishment under conditions of primitive peasant agriculture we have the difficulty of providing more land for the over-flow of the people from the over-populated areas adjoining Lake Victoria. You may find this difficult to understand when the density of population in Tanganyika is only 14 per square mile. It is true that there are thousands of square miles of unused yet cultivable land with reasonable rainfall having no population at all. But it is covered with heavy bush and trees. The African with his axe, hand-hoe and fire cannot clear more than an acre or so of it in any one year. He crops this until the soil is exhausted and then moves on. For the most part, such land is waterless and in many areas the womenfolk have to travel several hours each day to fetch a gourd of water for drinking purposes; they cannot afford to put down bore-holes or to build reservoirs.

Also there is tsetse over five-sixths of Tanganyika, so that the African cannot use ox-drawn implements. Under such conditions it is either the hoe or the tractor. But the African cannot afford a tractor, and the Tanganyika Government have said that large-scale clearing of the Morsitans-infested Miombo bush is only possible by the bulldozer, but that this is uneconomic.

In short, we still have African agriculture as it was a thousand years ago; except that cash needs for the payment of tax, the purchase of clothes, and the provision of administrative, technical and social services from abroad, have been added to the old tribal subsistence economy. The condition has been one of stagnation because the line has been taken that the necessary ameliorative measures—of implements, fertilizers and water—cannot be afforded. Now we see that the soil of Africa can no longer carry the burden by itself. Even if the economy of East Africa only is concerned and production for the world market is ignored, the point has been reached where it is not what Africa can afford to have, but what she cannot afford to do without. Again on the economy of East Africa alone, the cost of

solving the problem would be an impossible burden to place on the British taxpayer. The groundnut scheme entirely alters the position. It strongly appealed to me as providing the opportunity for the economic application of scientific principles on a regional basis—3,250,000 acres of virgin land, about two-thirds the size of Wales, are to be developed.

I can assure you that the Directors of the project are in no doubt that science must be fully harnessed to the scheme to ensure its success. In the near future Advisory Panels of eminent authorities in this country on agriculture, education and sociology and medicine will be established to advise them. The agricultural panel will cover the following subjects: soil chemistry, agronomy, nutrition, plant pathology, entomology, economics, statistics and mechanization.

It is significant that the very first appointment made by the managing agency was that of Dr. Bunting as Chief Scientific Officer. Other scientific appointments already made are Plant Pathologist, Entomologist and Statistician from Rothamsted; a Chemist from the Veterinary Research Laboratory in South Africa; an Agronomist from Southern Rhodesia; a Soil Chemist from I.C.I.; a Soil Conservation expert from Witwatersrand University; five Soil Surveyors, two from Holland; a Meteorologist and a Geologist from East Africa, and an Analyst. A Plant Breeder from Burma or Australia will shortly be appointed, and an Agricultural Engineer from this country. This is regarded as a start; we shall not decide on the full scientific staff until these research workers have studied the problems on the spot, and have indicated their needs and the Advisory Panels have expressed their views.

Dr. Keen, Director of the new East African Research Organization, Dr. Bunting and myself are seeing to it that there will be close co-operation between that body and the groundnut scientific workers.

The 3,250,000 acres involved will be laid out in units of 30,000 acres each on a soil and water conservation basis. Contour cultivation and strip cropping will be followed. In the first instance, a simple rotation of half groundnuts and half grass will be followed—whether this will be on a basis of two years or only one of groundnuts has yet to be decided. We hope to replace grass on Dr. Crowther's suggestion with dwarf sorghums which can be combined, or, on Professor Blackman's suggestion, with sunflower.

To start with, we are applying four cwt. of lime where tests indicate this to be necessary, and one cwt. of superphosphate and half a cwt. sulphate of ammonia direct to the groundnuts. A large number of fertilizer experiments are now being laid down. It is hoped that smaller dressings will be effective; also, we are planning for the utilization of local phosphate deposits and the local manufacture of calcined phosphate. If successful this should provide a considerable saving in our fertilizer bill which, for next year's planting of 500,000 acres, will be over a million pounds sterling.

The question of pests and disease has received especial attention. Last March, for instance, I paid a visit to South Africa to discuss the problem with the Union authorities, particularly Professor Phillips of Witwatersrand University, Dr. Rose of the Union Soil Conservation Department, and Mr. Sellschop of Potchefstroom Experimental Station. Considerable quantities of groundnuts are planted on the Springbok Flats, in fields of up to 300–400 acres, sometimes for several years in succession. Neither Rosette disease, transmitted by an Aphis fly, nor Sclerotium or Wilt disease are now the danger they were a few years ago. The latter is controlled by close planting within the row to enable the predator ladybird to move freely from plant to plant in search of the Aphis. Wide spacing is then permissible between the rows, and is necessary for mechanical cultivation. Previously in East Africa we had thought that close planting both within and between the rows and the absence of clean weeding was necessary to produce a humid micro-climate which was considered to be inimical to the Aphis vector. At the same time we are negotiating with a commercial concern already operating in the Sudan and Southern Rhodesia to provide us with what we regard as a "fire brigade" service to deal with sporadic outbreaks.

This is a very sketchy picture of the groundnut scheme, but I hope it is sufficient to leave no doubt that we want to secure the interest and assistance of British scientists. I hope, too, that the gaps in my description of the technical side will draw from you questions on specific points of doubt, also of criticism and even warning. I say criticism and warning because we are most anxious to rectify anything which might be in error. We shall always welcome suggestions, however critical they may be, particularly from members of the British Society of Soil Science.

GRASS BURNING: SOME UGANDA EXPERIENCE

By G. B. Masefield, M.A., A.I.C.T.A., Agricultural Officer, Uganda

(*Received for publication on 12th October*, 1947)

Although a great deal of practical knowledge exists throughout East Africa on the subject of grass burning, there are, so far as I am aware, no written summaries of it available. Particularly in teaching students on this subject, I have found the difficulty that there is no literature to which to refer them. It is therefore proposed in this article to try to present a summary of experience on the problem as it is known in Uganda. In other parts of the tropics, and even in other East African territories, where conditions are different, divergent views are no doubt held on many of the points at issue.

In the first part of the article, extensive burning of grasslands or grazing land only will be dealt with. Localized burning to clear vegetation off small areas prior to cultivation will be considered later.

Reasons for Burning

It seems logical to start with the reasons why burning is normally carried out, or the alleged advantages accruing from it. These may be listed as follows:—

(1) To burn off a mat of dead grass which covers a pasture, and to stimulate the growth of fresh young herbage. This is probably the main reason why grass is fired by Africans in Uganda. There appears to be no experimental evidence that the advantage alleged is actually obtained by burning; indeed, I believe that in South Africa there are authorities who maintain that the supply of fresh young forage is as great or greater where grass is not burned. Nevertheless, under Uganda conditions most observers are agreed that burning does produce the desired effect.

(2) To prevent the encroachment of forest or thicket growth on grazing lands. This is a major consideration only in limited areas of Uganda, such as the Sesse Islands where with a rainfall of over 100 in. forest encroachment is so serious that it is difficult to see by what other practicable means the inhabitants could preserve their cultivated clearings and their grazing land. In the northern areas of Uganda, burning has also been advocated as a means of checking the encroachment of thorn scrub (mostly *Acacia* spp.) on grazing land; experiments are in progress to determine how far it does actually accomplish this.

(3) Probably much grass is deliberately burned each year to avoid an accumulation of inflammable material which, even if it can be preserved for some years, is inevitably fired at last either accidentally or maliciously. Such material may produce a conflagration which is far more dangerous to houses and crops and also to the soil than a lighter annual burn. The force of the argument can hardly be denied.

(4) Grass is fired by hunters with the object of driving out animals to a place where they can be dispatched. The animal which tempts hunters to do this over the largest areas of Uganda is the edible rat (*Thryonomys* and *Choeromys*). This is a frequent reason for grass burning in Uganda.

(5) It has been claimed that an advantage of grass burning is that the tick population is reduced, and the health of grazing animals thereby improved. The extent of the reduction has not, so far as I know, been investigated experimentally.

(6) Other animals harmful to man, crops, and stock are destroyed in grass fires. Besides insects, these may include rats, snakes, and the nests and eggs of harmful birds.

((7) Other advantages to the grassland itself are occasionally claimed. Thus it is reported from Kenya that the valuable grazing grass *Themeda triandra* ("red oat grass") does not germinate its seeds readily until they have been burned.

(8) It can be argued that the ash from the burnt grass acts to some extent as a fertilizer for the soil.

(9) Grass may be burned maliciously in the hope of destroying an enemy's house, crops, stock, or grazing.

(10) Grass may be burned accidentally by failure to put out a cooking fire or by throwing away cigarette ends, lighted matches, etc.

(11) Grass fires can be caused naturally, e.g. by lightning or by the sun's rays being focused through a piece of glass, such as a broken bottle.

(12) As a special case, grass burning aimed at the destruction of thickets is practised in some parts of Uganda under Government supervision for the control of tsetse flies. A burn of maximum intensity being desired for this purpose, the fires are started late in the dry season and earlier grass burning is forbidden in these areas by local rules.

Reasons Against Burning

The reasons that are usually given against burning may next be listed as follows:—

(1) Burning away the dead grass deprives the soil of a valuable eventual source of humus.

(2) By removing the vegetative cover, burning exposes the soil to erosion, which is often very serious, especially on steep land.

(3) Burning oxidizes the organic matter in the topsoil.

(4) Burning leads to soil impoverishment by killing the micro-fauna and flora of the topsoil.

(5) Burning exhausts soil fertility by constantly stimulating new growth of grass to replace the burned material.

These first five arguments represent the weight of the criticism against grass burning.

(6) Burning often spreads beyond the necessary grazing area, and may destroy tree growth which is protecting the soil from erosion, or even valuable forest; it also often damages crops and even houses.

(7) Burning destroys useful animals, such as insects and birds which exert a biological control on crop pests.

(8) In some areas, regular annual burning is said to lead to an ecological deterioration of grasslands. Thus I have been told by agronomists of the Belgian Congo that in the northern savanna regions it leads to dominance of *Loudetia* spp. in almost pure stand, whereas unburned pastures are dominated by *Setaria sphacelata* and provide a bigger bulk of herbage; in the Kivu region it is said to lead to dominance of the couch grass *Digitaria scalarum*, which is a menace on cultivated land and not very useful as a pasture grass.

Summing-up

In attempting to sum up the present state of responsible scientific opinion on these contrasted aspects in Uganda, I think it would be fair to say that all are agreed that grass-burning is undesirable where its objects can be achieved by other means. For example, where cattle are grazed in fenced paddocks under efficient supervision, the rate of stocking can be continually adjusted so that the grass is kept short while still providing a good soil cover; mowing is of course another means of achieving the same object. Under such conditions grass-burning becomes as unnecessary as it is on English farms to-day. On the other hand, it is generally admitted that in ordinary native practice arguments (1) and (3) in favour of burning make it a necessity to which there is no practicable alternative at present. It is therefore accepted as inevitable at this stage. But there is good and bad burning; and the main stress is laid to-day on the necessity for using only carefully controlled methods when grass burning is carried out.

Present Methods of Burning

Before discussing the methods advocated as best in grass burning, it is perhaps appropriate to give some description of existing practice. From late in 1940 to the middle of 1942 I spent a large proportion of each month in camp on a hill-top at Nsangi in Buganda which commanded an exceptionally wide view over the surrounding country, so that it was possible to observe accurately the incidence of grass burning over a wide area. Continuous records of these observations were kept from February, 1941, to February, 1942, and enabled various deductions to be drawn.

Practically all grassland in sight was burned over once during the year, such small patches as were omitted appearing to be more by accident than design. On the other hand only one very small area was burned twice, again probably by accidental spread of a fire intended to deal with an adjacent area. The largest areas were burned, as expected, in February, i.e. towards the end of the dry season; this large-scale burning was carried on also into the first half of March, which happened to be dry that year. But there was no month in the year in which some grass fires were not observed; and a subsidiary peak occurred whenever there was a longish spell of dry weather, particularly in July to September. After a short period of observations, it struck me that there were fewer grass fires on Sundays than week-days, and over the whole year the average number per Sunday proved to be only just over half that per week-day, indicating a considerable observance of the sabbath in this predominantly Christian area. The majority of fires were started in the early afternoon, which is what one would expect as the grass is then free from dew and at its driest. A minority of fires were lit in the late morning and late afternoon, and a few lingered on till the night. But there was no evidence of fires being deliberately lit at night, as is often the case in the Eastern Province of Uganda, perhaps because there is less dew in that hotter drier climate, or possibly intentionally to obtain a lighter burn under those drier conditions.

A number of swamp fires, mostly of papyrus, were seen during these observations. Inquiries elicited the information that in old days swamp fires were sometimes deliberately lit either to obtain papyrus ash for making soap or extracting salt or to promote an even growth of young papyrus stems for making rope, thatching, etc. Modern papyrus fires are however considered to be almost always accidental, presumably in most cases by the spread of fire from adjoining grassland.

Controlled Burning

The chief point usually advocated in controlled burning is that it should be done early in the dry season. The chief advantages obtained are that the burn is then lighter, as the grass is not quite so dry as later on, and that a vegetative cover has time to spring up again before the heavy rains bring serious risks of erosion. In Uganda, experience has shown that approximately five weeks after a burn there is sufficient young grass to protect the soil from erosion and to provide some grazing: an interval of about this length between burning and grazing would probably hold in most tropical countries. A suitable time for "early burning" in the Buganda Province is usually about the middle of December, or after Christmas if the second rains are unusually prolonged.

One exception to early burning is where firing is used for tsetse control, as mentioned above. Another is in cases where the burning of all grazing areas at one time would leave the cattle temporarily without pasture; in this case rotational burning must be practised, and some areas will unavoidably have to be burned later in the dry season. This consideration does not arise where the cattle have alternative pasturage available, e.g. leys resting from cultivation, roadside verges or other odd bits of land, or grassland which has been burned at some quite different time of year. Other exceptions to the rule may possibly arise; for example, it is again reported from Kenya of *Themeda triandra* that it recovers better from a late than from an early burn.

A special case arises where grass burning has to be considered in relation to forest growth. In Uganda a number of areas of savanna woodland with scattered trees have been taken over as forest reserves, and it is desired to thicken up the tree growth. Observations by the Forestry Department have indicated that while late burning prevents this, early burning is not incompatible with it. Large areas are therefore early-burned under control each year, in order to obviate the inevitable risk of late burning which would otherwise occur. In 1939 it was already possible to state in the Annual Report of the Department that one area had thickened up so much that there would soon not be enough grass left to burn. In 1944 early burning was carried out over 1,180 square miles of woodland reserves at costs varying from 30 cts. per square mile up to Sh. 15 in one small and difficult area.

Having decided on the season, the next point is to choose a suitable day for grass burning. There should be a wind sufficient to spread the flames, but not a very strong one. A precaution which at present is almost universally neglected, is to warn the neighbours that a fire is about to be started, and thus give them a chance to protect their crops and buildings if the wind should rise or the fire spread to unexpected areas. A group of people who have been fore-warned can generally beat out the necessary sector of the fire if these dangers arise. At present, damage to crops by grass fires is frequent, coffee and cassava being perhaps the commonest sufferers in the Buganda Province.

In a properly controlled fire, planning of firebreaks is the next point. If possible, the area chosen for burning should be a unit which is isolated by natural firebreaks such as roads, footpaths, swamps or streams, cultivated land, high forest, etc. If these firebreaks do not exist on all sides, they must be created artificially. The chief one to attend to is the firebreak on the down-wind side. Quite a narrow swathe of slashed grass will often be sufficient for this if the wind is gentle, and provided that beaters are at hand to put out immediately any local spread of fire across this; controlled burning should *never* be attempted without an adequate number of people present. The effective width of this firebreak is now increased by firing the grass on the side of it towards the area to be burned. Such an up-wind fire usually dies out after penetrating a few feet into the grass, but has served its purpose by increasing the width of the firebreak.

All is now ready to start the main down-wind fire. This is done by a few men who proceed to the up-wind firebreak or edge of the area, and who in Buganda are usually armed with torches consisting of a bunch of dry grass tied over the end of a faggot of dry elephant-grass stems. A few men are stationed as guards along the flanks of the area being fired, but the bulk of the force is concentrated at the down-wind side, which is the danger-point; these are all armed with leafy branches for beating out any fire that spreads outside the area.

The above is of course a skeleton plan which is susceptible of many variations. Experience has shown that by its use, under careful supervision, blocks of up to ten acres or so can be burned very exactly, with deviations of only a few feet from the boundaries originally decided on. Much larger blocks could probably be burned pretty accurately, but if there is only one supervisor it becomes more difficult for him to keep his eye on all danger-points at once; and since smoke often drives away the beaters from sections of the down-wind line at a time, and they may even for spells have to take refuge at the corners, it is more difficult with a long line to ensure that there is no spread along this dangerous side.

Methods of Protection from Fire

For the protection of plantations, etc., from fire at all times, firebreaks are the method generally advocated. These may consist of earth wholly bared by ploughing or hoeing, or they may be made merely by slashing the grass where this is not in very inflammable condition. Unfortunately there appears to be no experimental evidence on the width which is safe for firebreaks under different conditions; and though much practical experience must exist, it has not usually been recorded. Firebreaks from about five to seven yards in width are in common use round plantations in Uganda, but are not invariably effective. A point to be remembered is that on steeply sloping land firebreaks should be wider than on flat land, for the horizontal distance across them is less than the surface distance, and with elephant grass several feet high on the lower side its tops are often as high as the lowest vegetation on the upper side, and sparks may easily be carried across.

A common protective measure, when a fire is approaching buildings or other valuable property down-wind, is to set light to the grass near the buildings under a close watch, with the object of starting a small up-wind fire and creating a firebreak as was explained in the method for burning grasslands.

Personally I consider that the only really effective protection against fire is a system of patrolling guards, frequently supervised, on duty in all but the wettest weather. Trustworthy men must be employed, and dismissed at once if found to be unreliable. They need not come on duty until mid-morning but must remain till sunset, and of course reliefs on Sundays must be arranged. If such a guard notices a dangerous fire approaching the protected boundary, he at once goes for assistance, which on an estate or farm employing a permanent labour force, should be quickly forthcoming. Experience in the Nsangi soil conservation area has shown that by such a system under reliable supervision, areas planted with young trees or reserved for forest regeneration can be completely protected from fire over several years, which could probably not be accomplished by any other means. In the case of valuable plantations, the system is probably quite economic.

Grass-thatched roofs are of course always liable to be set alight by sparks from grass fires, and many houses are destroyed this way in Uganda every year. Individuals of many tribes try to reduce the danger by thatching their houses with plantain leaf-bases or with papyrus, which are less inflammable than grass but more difficult to procure. There are recipes for treating grass thatch with alum solutions to make it less inflammable, and of course the advantages of iron or tiled roofs are obvious.

Burning Prior to Cultivation

Burning prior to clearing land for cultivation is universally practised in the elephant grass (*Pennisetum purpureum*) areas; for without the use of heavy mechanical implements, there is no other practicable method of clearing such land. Some controversy has existed as to whether it is better to burn the elephant grass standing (which is the usual native practice) or to cut it first and burn it as it lies on the ground. Arguments for burning it standing are that this uses less labour and destroys less potential humus-forming material. Some also consider that this method makes subsequent cultivation (especially by plough) easier, as the stems can be pushed down all in one direction whereas when felled first they lie all ways; an ox-drawn log pulled over the plot after burning is also said to facilitate cultivation. Arguments for cutting the elephant grass before burning are that it is easier to prevent the fire spreading into adjoining areas, and that more material is consumed, for which reason some maintain that cultivation either by hoe or plough is easier.

In the short-grass areas, it is not essential to burn the grass in order to clear, but the grass is often cleared and then piled up in heaps which are lit as bonfires. Sometimes this is done especially for particular crops; for example in Kigezi district, some cultivators maintain that the resultant ash is a particularly good fertilizer for Eleusine millet, which is often the first crop taken on cleared land. It is probable, however, that this material would in most such cases be better used for building up trash bunds in the plots to prevent erosion.

A METHOD FOR THE PREPARATION OF SILICOPHOSPHATE ON FARMS

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Earlier work at the laboratories of the East African Industrial Research Board and at the Scott Agricultural Laboratories has shown that when Uganda Rock Phosphate and Magadi Ash are heated together, with or without the addition of water, the sodium carbonate reacts with the phosphate-containing minerals present in Uganda Rock Phosphate in such a way that new synthetic sodium-containing compound or compounds are formed which contain the essential nutrient in a much more available form. The "citric-soluble" phosphoric oxide content can be increased from about 4 per cent to 5 per cent in the ground Uganda Rock Phosphate to 18 per cent to 20 per cent in the prepared silicophosphate, the latter material having some 80 per cent to 90 per cent of its total phosphoric oxide present in a form that is soluble in citric acid and readily available to plants. Pot culture trials with cereals have shown that the "citric-soluble" portion of P_2O_5 contained in silicophosphate is about equally early available as that in superphosphate and that it is somewhat more available for use with the more acid, highly coloured, lateritic soils which readily fix added soluble phosphates. Field experiments with Silicophosphate prepared in a small rotary kiln at the East African Industrial Research Board Laboratories have shown that it is a suitable phosphatic fertilizer for local use.

A note on "East African Supplies of Phosphates and their Utilization" with a reference to a new synthetic phosphatic fertilizer obtained by calcining Uganda Rock Phosphate and Magadi Ash appeared in the April, 1945 issue of the East African Agricultural Journal.

Owing to the scarcity and high cost of imported phosphatic fertilizers, farmers have been pressing for the early production of this new fertilizer on a large scale. However, owing to certain technical difficulties in the manufacture of silicophosphate in a rotary kiln on a large scale, which have yet to be overcome, it is not possible to start production by this method at present. On the other hand, the process itself can be simple and, as long as one is not concerned with possible damage to an expensive plant and is also prepared to use a material with a varying and generally lower content of "citric-soluble" phosphate, there is no need to wait for the erection of a large, expensive plant in East Africa.

It has been shown that a phosphatic fertilizer with a high content of "citric-soluble" P_2O_5 could be prepared by heating certain proportions of Uganda Rock Phosphate and Magadi Ash at a temperature of about 850°–900°C., the time of heating required depending much upon the mass of the units used. Some factors, such as the necessary proportions of Magadi Ash to Uganda Rock Phosphate; the making of rapid drying moulded bricks based on the crystallization of the soda in the Uganda Rock Phosphate/Magadi Ash and water paste thus cementing the particles; the drying of the bricks and the heating necessary to obtain high conversion, had already been worked out at the two laboratories mentioned above. This fundamental information was based on the preparation of small quantities of silicophosphate heated in an electric muffle and there was need to develop a similar process which could be carried out on a practical scale by individual farmers using a kiln to replace the laboratory muffle. In the case of such mass production, there was need to find out the proportions of ingredients necessary under the kiln method of production, the best method of mixing, the size and shape of the units and their moulding and drying, the design of a suitable kiln and the technique of stacking and firing that was necessary to give the most economical high degree of conversion of the contained phosphate into a "citric-soluble" form.

There are certain inherent, practical difficulties in firing units made of mixtures containing crystals of sodium carbonate. The made brick contains little or no colloidal materials that help setting on air drying and the cohesion that is obtained is due to the binding of the brick by water-containing crystals of soda. On gently heating, these crystals melt and the mass loses its original good cohesion and there is a stage when the brick becomes pasty before it acquires a new kind of cohesion due to further firing. Unfired bricks also contain some free water, more especially in damp weather or if they have only recently been made. Both this water and the water of crystallization have to be driven off during the early stages of

firing thus giving a high humidity so precautions must be taken such that the very humid warm gases do not cause excessive condensation on, and hence the softening and collapse of bricks further away from the source of heat.

Certain Considerations Involved in Mixing, Drying, Stacking and Firing

Though a simple kiln-burning method for making silicophosphate on the farm resembles that of brick making, involving the mixing of raw materials, the adding of water to make moulded units which are shade dried, stacked, and fired in a kiln, there must be a special technique throughout to allow for the special properties of the ingredients used. It would be possible to have a specially designed plant, in which the mixture is heated in the dry state. However, when a simple kiln is used, as must be the case on farms, it is necessary to have a conveniently large heap of units of the mixture, through which heated gases can be passed to remove moisture and to bring about the necessary chemical reactions that result in the formation of new compounds with the phosphate in a much more available form.

The proportions of Uganda Rock Phosphate and Magadi Ash necessary vary with the total phosphate content of the milled ore, the economic temperature and duration of heating, and the degree of conversion aimed at. A saving in the cost of firing can be made good by adding a greater proportion of Magadi Ash as long as there is only a limited amount of free, uncombined soda remaining in the fired product. The theoretical requirements necessary, when not allowing for the economy of the conversion, are about equimolecular proportions of contained total phosphoric oxide and pure sodium carbonate. Thus, 142 parts by weight of contained phosphoric oxide would require 106 parts of anhydrous sodium carbonate, or 100 parts of Uganda Rock Phosphate with, say, 28.4 per cent of total P_2O_5 would require 21.2 parts by weight of sodium carbonate. After making allowances that obtain in practice, the optimum proportion of commercial Magadi Ash necessary per 100 parts of ore is appreciably higher; it is about the same as the declared percentage of total P_2O_5 in the ore used. Thus, 100 parts of milled phosphate ore of the composition referred to above, would have to be mixed with 28 or 29 parts of commercial Magadi Ash. Supplies of Uganda Rock Phosphate at present available for the manufacture of silicophosphate contain some 24 per cent to 26 per cent of total P_2O_5 and, unless the composition is known in which case the amount of soda can be calculated, it is suggested that farmers use a 4 : 1 mixture by weight of ground Uganda Rock Phosphate and ground commercial Magadi Ash. Crude sesquicarbonate or "Trona" can also be used but as this material is at present not apreciably cheaper per unit of contained alkali and, as it has to be crushed on the farm and also presents certain difficulties in drying and firing, it is recommended that Magadi Ash only be used for silicophosphate manufacture. The proportions mentioned above have to be mixed with the minimum amount of water that allows the freshly made paste to be conveniently moulded. This will amount to about 15 parts by weight of water to 100 parts of the dry mixture. Special precautions must be taken in adding the water as no more paste must be made than can readily be moulded as, on watering, the mixture warms up and sets very rapidly as crystals of hydrated sodium carbonate are formed.

The size and shape of the moulded bricks are important. If too small, they become weak when heated under a load and if too large, it takes too long for the inner portion to acquire a sufficiently high temperature for a good conversion. Large size can be partly compensated for by lessening the maximum distance from the outside of the brick by having the units pierced with one or two holes. This makes for quicker air drying, a more rapid heating of the inside of the bricks, a more even passage of the heated gases throughout the heap and also results in a higher degree of conversion. Again, such holed bricks at the bottom of the kiln, which may become sintered due to overheating, are more easily crushed to a convenient size for grinding. It is found that units of a standard brick size, that is, $9 \times 4\frac{1}{2} \times 3$ inches with two evenly spaced $1\frac{1}{2}$ inch diameter holes connecting the two larger faces are of a suitable size for safe firing and also for making, handling and crushing. Newly made bricks, after setting, must not be placed in the sun or warmed in any way as a secondary heating causes some of the binding crystals to melt and on cooling again the bricks tend to disintegrate and cohesion is reduced. The bricks set very readily and after some two hours, they can be open stacked up to a height of about 3 feet, in narrow lines in a shelter. In the kiln, air-dried bricks must be stacked

rigidly so that the danger of slipping is minimized while allowing ample space for the passage of heated gases.

As regards firing, it is not difficult to burn silicophosphate bricks if these are subjected to a preliminary heat treatment in single layers or if a heated kiln is loaded one or two layers at a time. The difficulty arises only when a large mass of bricks under load has to be heated and, for reasons of economy in time and costs, it is necessary to work out a method that can be processed in one operation. In firing, the aim is to arrange for an adequate draught so that there is a rapid vertical removal of the humid gases during the early stages of firing, followed by a system of adjusting the flow of heated gases in the kiln so that all portions of the load are adequately heated. The kiln must be strongly built so that a large number of firings can be made with the minimum amount of repair work.

Mixing, Moulding and Air-Drying

The special utensils required are limited to a container such as a shallow wooden box for wet mixing, two open, double-compartment brick-making moulds of a standard size together with boards and a split, springy, hollow cylinder made out of iron sheeting. Wet mixing can, if necessary, be done on a cement or wooden floor. It is essential to have a cool sun and weather-proof shelter in which to stack the bricks for drying.

On the basis of a ratio 4 : 1 of Uganda Rock Phosphate and commercial Magadi Ash, it is convenient to empty out 8 cwt. of Uganda Rock Phosphate and 2 cwt. of Magadi Ash. These are thoroughly mixed in the dry state, breaking up any soft white lumps of soda which may be present. The next step of adding water to the dry mix must be carefully carried out as no more must be made into a paste than can readily be moulded within three or four minutes. According to the number of labourers and especially their efficiency in "pugging" the stiff paste, some forty to sixty pounds of the dry mixture is shovelled into the shallow container and water is added while the whole is rapidly and thoroughly mixed together or "pugged" with small shovels and by hand. The thick paste is then quickly packed into the mould. No more of the mixture is wetted until the previous batch has been dealt with. The amount of water used must be kept to the minimum necessary to give a workable paste. The moulds and the boards on which the paste rests are emptied on to rough, wooden planks or on to the floor in the drying shelter. A brick press might also be used to give an initially drier brick. After about five minutes, the bricks are sufficiently set for piercing with the split metal cylinder, making two evenly spaced 1½ inch diameter holes. Six labourers can prepare sufficient bricks to yield about one ton of prepared silicophosphate in one day. After a couple of hours, when the bricks have become hard on the outside and greyish in colour, due to the formation of soda crystals on their surface, they can be stacked up loosely in narrow lines, allowing plenty of ventilation, up to a height of about 3 feet. Old air-dried bricks are more suitable for firing, hence it is desirable that the raw bricks be made at a time when labour is convenient a few weeks before burning time. Should more bricks be required to make a kiln load, then three or four days' drying in single layers, with turning would give sufficiently strong bricks. In all cases, bricks must be dried in the shade. It is noted that the air-drying of silicophosphate bricks is easier and requires less drying space than in the case of building bricks.

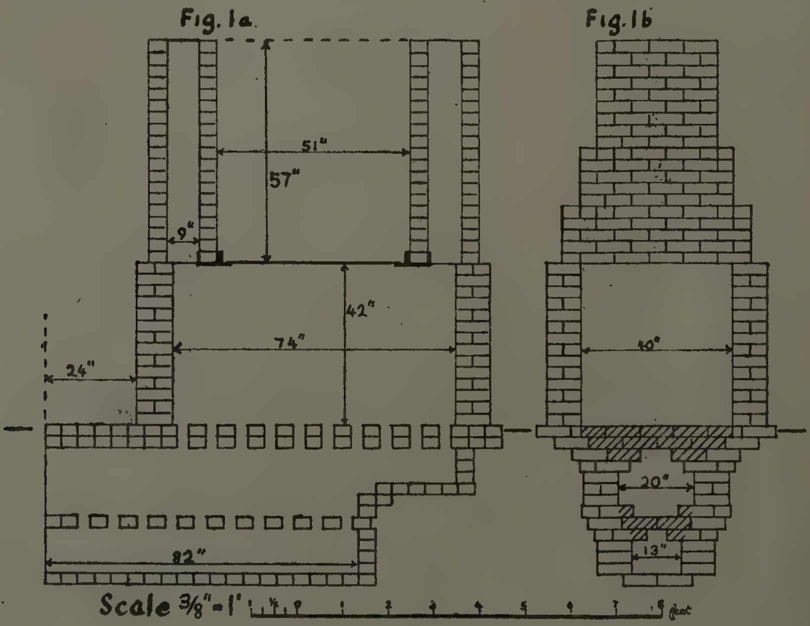
The S.A.L. Kiln

Observations have been made on the efficiency and the nature of the total burn obtained with a succession of small kilns, and alterations in design have been incorporated as found necessary. The final design is illustrated on a scale of ½ in. to the foot in Figures 1*a* and 1*b*. These show sections along the length and across the kiln, respectively. The account of the kiln given below must be read in conjunction with these illustrations. The extreme outer dimensions are, length 8 ft. 10 in., width 4 ft. 10 in., and height, including chimneys, 11 ft. 9 in. The internal dimensions of the kiln are length 6 ft. 2 in., width 3 ft. 4 in. and height 3 ft. 6 in. with a total capacity of 72 cubic feet or a little over one ton of silicophosphate. The size and shape of the firebox and ash pit and their forward extension are given to scale in the illustrations; these also show the pattern of brick laying necessary. The above-quoted dimensions are those of the final kiln built at the Scott Agricultural Laboratories and, of course, need not be strictly adhered to, but the general proportions and the design must not be unduly altered. It would be unwise to attempt to increase the height and width by more than a few inches. Should a kiln of a somewhat larger capacity be desired, then it can be made longer by a foot or two, provided that there is a corres-

ponding increase in the length of the firebox. The essentials of the kiln are that it must be relatively shallow and narrow with a firebox that extends for at least two-thirds of the full length of the kiln and with a raised extension for the remaining distance below the rear of the kiln. There must also be a forward extension or vestibule to preheat the gases and to ensure the proper heating of the front part of the kiln load.

So as to obtain adequate upright draught through the kiln in the early stages of firing and for the subsequent heating of all parts of the kiln, especially the forward portion, it is found necessary to have two chimneys situated at distant ends of the kiln. This system makes it possible to regulate the flow of the hot gases as required. Another essential of the design illustrated is that the top of the kiln between the two chimneys is covered by a loose metal sheet or lid. This system gives ample space for loading and unloading and the lid can also be used as a hot plate for preheating any weak, green bricks and those which are not sufficiently dry for placing in the kiln. A 3/8ths inch thick 4 ft. by 4 ft. standard size iron sheet that can be purchased locally can be used, or else two thicknesses of straightened out and cut old corrugated iron sheets. There is need for two pairs of 5 ft. long angle iron or iron bars to support the nearer sides of the two chimneys and, unless considered unnecessary, two more lighter iron bars to support the sheet metal cover. The design for the firebox and ash pit is shown in Figure 1*b*.

Three methods of building brick arches over the fire were tried out, namely, the moulding of one-piece low arches made to fit the kiln, low keyed arches and, thirdly, the pattern illustrated. It was found that the latter system is sufficiently strong and more easy to build and also to repair if damaged when removing any sintered silicophosphate bricks lying on the firebars. It was found necessary to have a second layer of firebar bricks extending the full length to give the necessary rigidity. If it is known that local bricks are not sufficiently heat-resistant, then low grade refractory bricks must be used for the firebox. At least the ash pit and firebox should be built below ground level, in which case the soil from the excavation can be used for the making of earth mortar and plaster. When the kiln space is above ground level, it is necessary to have walls of two-brick width built on the inter-lock system; the chimneys may be built of single



bricks. It would be convenient to build the kiln into sloping ground or into a large anthill so as to reduce the loss of heat from the kiln walls. In this case, the side walls and rear kiln wall can be one-brick width only on a double brick foundation. The number of standard size bricks required to build a kiln with nine inch walls throughout as described in the above notes, amounts to some 1,500. The building of the ash pit and firebox, involving a particular pattern of brick laying as illustrated, needs careful supervision. It will be noted that the base of the firebox has brick firebars one brick deep and that the firebars at the base of the kiln are two-brick deep in the centre and three-brick deep at the sides. The spacing is 4½ inches wide bars with a spacing of 3 inches. Figure 1*b* shows a cross section through the fire bars, the hatched bricks in the illustration are missing between the firebars.

After the completion of brick laying up to the base of the kiln space, the remaining work is straightforward, except that provision must be made for inspection holes so that one can note and regulate the heating of different portions of the kiln load, as required. There is need to have two small holes of the cross section of a brick located some 15 inches from the base at a quarter distant and three-quarter distant from the front end, on one side of the kiln and also one inspection hole in the centre at each end of the kiln placed about 9 inches below the top of the kiln. The apertures can be closed by a loose brick placed lengthways. In the case of a partially buried kiln on a slope, the front hole and the foremost side hole—the latter perhaps located a little higher up—can remain and there can be a rear side hole just below the top of the kiln. When the kiln is built into sloping ground, a useful adaptation of the rear chimney is possible. The hot gases can travel up a gentle slope through a broad shallow trench surmounted by a length of straightened out corrugated iron sheeting with the upright chimney placed further to the rear. In this case, old corrugated iron can be used to make the chimney. This would provide extra length of a metal hot plate for the preheating of weak silicophosphate bricks. The draught through the kiln is regulated by means of pieces of metal sheets placed on the tops of both chimneys. The 4 feet by 4 feet iron sheet between the chimneys is sealed with earth plaster and when the kiln is fired, this space is covered with one layer of green bricks or with a six inch layer of earth.

STACKING

Correct methods of stacking and firing are essential. One feature of the kiln design is the convenience of stacking through the 4 feet square opening between the two chimneys. The actual pattern of stacking can be varied as long as the load is firm against side slipping and has adequate air passages between the units. There must be a slightly more distant packing near the kiln walls and closer packing immediately above the firebox. The system of packing used in the later trials at the Scott Agricultural Laboratories was as follows:—

The bottom layer was composed of parallel rows of silicophosphate bricks on edge placed end to end along the length of the kiln with a space of 1½ inches in the middle and up to about 2½ inches at the sides. The second layer was placed again on edge across the first layer on the interlock system with a fourth to a third of a brick length overlapping, the overlap being greater along the middle of the kiln. The third layer was placed across the second layer with similar interlocking and so on for the fourth and fifth layers, the odd numbered layers being placed lengthways along the kiln and the even numbered layers being placed across the kiln. All bricks were placed with the prepared holes running in the horizontal plane. This system of somewhat closer packing along the middle throughout tended to check a direct upward movement of hot gases from the firebox and brought about a greater flow towards the sides of the kiln. As the heap was built up, pieces of fired silicophosphate bricks were wedged in against the kiln wall to check slipping. According to the width of the green bricks used, the five layers on edge will give a heap of about 28–30 inches high. A sixth layer is now placed flat across the kiln, leaving about the same amount of air pockets. It has been found that, in practice, it is difficult to maintain the uppermost layer of bricks at a sufficiently high temperature for high conversion and, therefore, it is recommended that old underfired bricks from a previous burn be used for the seventh, uppermost layer. The stack will now be within about 6 inches of the top of the kiln. More broken, underfired bricks from a previous burn are placed on top up to within an inch or two of the iron sheet in the middle of the kiln but a space of at least some 3 to 4 inches must be left under the chimneys. If, in

practice, it is found that the sixth layer is also underfired, then the height of the kiln could be reduced by some 6 inches and only five layers of green bricks burnt at a time, these being covered by old, fired bricks.

Previous to the firing of the kiln, it is necessary to check on the evenness of the passage of gases through the mass. This is done by having a small, smoky, cool fire along the full length of the firebox for a few minutes only with the metal sheet off. The distribution of the smoke is noted and any channels carrying excessive amounts of smoke are partially blocked with bits of fired bricks. The metal sheet is now placed in position and sealed with puddled earth.

Firing

During several trial burns carried out, it was found that there must be a special technique in firing so that the stack of bricks does not collapse locally due to softening during heating. The difficult stage is at the beginning when free water and water of crystallization derived from the heated bricks tends to condense on cooler bricks. The principle of firing adopted to overcome this inherent difficulty is to arrange that portions of the kiln are heated in turn and that the humid gases are made to leave the shallow heap as quickly as possible by providing ample chimney capacity. When the total load has passed through this stage, there is no difficulty except the possibility of the overheating and softening of the bottom bricks immediately over the firebars which also results in a partial sealing of necessary air passages. The adoption of a long kiln and firebox with two chimneys makes it possible gradually to extend the heated zone and to have a short upward flow of the humid gases through a shallow heap of bricks rather than an oblique flow through a longer distance between much cooler bricks.

A hot fire is started in the vestibule and forepart of the firebox with the front chimney fully open and the rear chimney closed. During this first stage, it is essential that dry, quick burning split firewood be used and to insure that there is no danger of the fire dying down once it is started. This fire is maintained for at least half an hour, after which it is gradually extended backwards to the full length of the 7 ft. firebox, while maintaining full heat. As the fire is made to extend backwards over a period of about one hour, the damper on the rear chimney is also opened. During this heating, the gases leaving the chimneys are very moist as can be shown by feeling the warm gases or by visible condensation on an iron object held above the chimney. The flue gases will gradually become less damp and the greater portion will leave by the rear chimney and it will be found that the back portion of the kiln, excepting along the rear wall, will heat up more readily. When the smaller flow of gases through the front chimney becomes appreciably less moist, though still slightly humid, the front chimney is almost closed and the full heat from the wood fire in the full length of the long firebox is maintained for about another three hours, making a total period of 4½ or perhaps 5 hours of firing. During this period, the zone of glowing bricks extends upwards: at about the third hour, the bottom layer will show a dull red glow, this glow reaching to the third layer in the fourth hour, and upwards to the fifth layer in about the fifth hour. By this time, the bottom layers of the heap will be cherry red hot. The rate of the heating of different portions of the kiln can be observed through the inspection holes. Owing to the backward flow of hot gases in the firebox, it will be found that the glow extends to a greater height in the rear part of the kiln and, according to the relative height of glowing bricks, the front chimney is opened for 1–1½ hours. By this time, there should be a glow at the base of the uppermost bricks for the full length of the kiln. During this heating, care must be taken so as not to overload the firebox, adding firewood at intervals of about a quarter of an hour only. It was found that overstoking with firewood in a kiln of this design was not only uneconomical in fuel but also less efficient in raising the temperature, more especially at the back end of the kiln. When the bottom layer starts to glow, intermittent stoking must be such that smoke appears for a few minutes only. Also, it was noted that it was better not to push fresh firewood into the back of the kiln as this resulted in smoky waste gases, indicating a lack of oxygen. Firing can best be done by letting the split logs start burning in the forepart and then pushing the half burnt glowing wood to the back of the firebox. When the kiln has attained its maximum temperature, the bottom layer will be cherry red in colour (about 1,000°C.). The greater mass of the kiln load will be red hot (about 900°C.) and the top layer but one will be dull red (about 800°C.). These conditions have to be maintained for a further

four to five hours, giving a total period of some ten hours from the start. During the period of maintaining a maximum temperature, it was found better to have intermittent stoking about every half an hour with the front chimney half damped and the rear chimney three-quarters damped and with the damper on the face of the firebox such that a smaller volume of air has to pass over the glowing charcoal in the ash pit to the firebox and then through the glowing silicophosphate bricks. If heating up has been slower than indicated above, there will be need for a longer period of stoking. There is need that most of the mass be maintained at a red hot heat for some five to six hours. When stoking is completed, all openings are fully damped so as to maintain the high temperature and the associated radiation of heat for as long as possible. In the latter trials the amount of woodfuel required worked out at just under one ton per ton of silicophosphate. However, there is no need to delay cooling once all parts of the mass has ceased to show any glow. The dampers and the sheet metal covering can then be removed to hasten cooling so that the kiln can be emptied.

Before unloading, the opportunity is taken to study the nature of the burn obtained. The general efficiency of the burn, as noted by the colour of the bricks, and whether there has been any local collapse, can be seen at a glance, but it is also necessary to break specimen once-burnt bricks from the upper layers to note whether the cores of the bricks are sufficiently fired. It is necessary that the reddish tinge be almost absent and that the bulk of the brick be a lustrous black in colour. This will show whether any longer heating, possibly of the front part of the kiln only, is necessary in the case of subsequent firings. When unloading, underfired bricks are put aside for further burning. Should the amount of such bricks accumulate, then some can be placed lower down in the kiln, such as distributed in the second and fourth layers and against the kiln walls. There may have been some sintering of bricks resting on the rear firebars. These bricks, which, incidentally, will have a very high degree of conversion, will have to be forced apart with a light crowbar using it across the kiln so as not to dislocate the brick firebars. After allowing for a portion of twice-fired bricks, one charge of the kiln described above will amount to about one ton of silicophosphate.

Crushing and Milling

It has not been possible to do any work on the best method of crushing and milling silicophosphate and, in any case, farmers preparing relatively small amounts for their own requirements will have to use whichever methods that are convenient to them. Failing some arrangement to use a rock crusher that may be in the district, the initial crushing will have to be done by hand, using a rammer or a heavy hammer, so as to give a material that can be taken by whatever kind of old mill that may be on the farm. A hammer or plate mill can be used but such milling is slow and the material has to be sieved and the coarser particles have to be put through again. There is no need for very fine milling as in the case of Uganda Rock Phosphate. For the present, it is suggested that farmers making this phosphatic fertilizer for their own use should mill such that all passes through a 40 meshes to the inch screen and that at least 50 per cent passes through a 100 mesh screen. The above screens are about equivalent to No. 30 and No. 90 I.M.M. screens.

It has been found that it becomes uneconomical to attempt to prepare silicophosphate with a very high decree of conversion to the "citric-soluble" form in small simple kilns, such as would be used on farms. Greyish coloured hard bricks from the base of the kiln will have 90 per cent or more of their total phosphate in the "citric-soluble" form, but bricks that are almost black, but with a tinge of red colour from the upper layers will have 65 per cent to 75 per cent only of the total phosphate converted. Any bricks of a dark, reddish-brown colour will have only 50 per cent to 55 per cent conversion and these, and any more reddish bricks, will have to be placed at the top of subsequent kiln loads and fired again. The colours mentioned refer to milled whole bricks and not the darker colour of the outsides only. Farmers should aim at an average conversion of about 80 per cent only. Thus, starting with Uganda Rock Phosphate with 25 per cent total phosphoric oxide, a greater weight of the calcined product would contain about 22 per cent of total phosphoric oxide, including some 17 per cent to 18 per cent of "citric-soluble" phosphoric oxide.

Under trial conditions with two labourers only, it has not been possible to obtain reliable figures on the capital cost of the kiln and this process of making silicophosphate. Allowing for the purchase of bricks and iron sheeting,

but making no allowances for old iron and supervision, the kiln might cost £6 to £8 to erect. The cost of the ingredients, including the transport charges, will probably average about £6 per ton of prepared silicophosphate and the cost of fuel and manufacture will probably amount to about another £2. Thus, unbagged silicophosphate might cost about £8 per ton, or Sh. 9 per unit value of "citric-soluble" phosphoric oxide. This compares very favourably with the present high cost of imported phosphatic fertilizers.

The making of silicophosphate on farms enables keen individual farmers to augment their limited allocation of imported phosphates so that they can be sure of a sufficient supply to meet all their requirements. However, when it will be possible to purchase a guaranteed high quality silicophosphate, prepared under properly controlled conditions, most farmers will probably be glad to purchase rather than to prepare their requirements. In the meantime, the preparation of silicophosphate or soda phosphate on farms can make good the present deficiency of suitable phosphatic fertilizers and can help to maintain yields on lands which are known to require this class of fertilizer.

ACKNOWLEDGMENT

Mr. G. M. F. Grundy, B.Sc., Chemical Assistant, was responsible for erecting a succession of small kilns of varying designs and also contributed to the special technique that is necessary in the preparation of silicophosphate by the kiln-burning method.

TEXTILE FIBRES FROM PROTEINS

The use of artificial fibres in the textile industry is a comparatively recent development. For centuries the fibres used have been obtained directly from plant and animal sources. The systematic investigation of the molecular structure of natural fibres has, however, brought about a remarkable change, a change which provides an excellent illustration of the value of close collaboration between industry and the academic research laboratories. To-day several artificial fibres, such as nylon and rayon, are being produced in great quantities and the number of such fabrics is increasing steadily.

Analysis of natural fibres by means of X-rays has revealed that the molecules from which fibres are constructed are long chains which lie along the lengths of the fibres in the same way as the latter lie along the length of the yarn. In natural fibres these long molecules are generally either carbohydrates, as in cotton, or proteins, as in silk or wool. Until recently the majority of artificial fibres have been of the carbohydrate type, but the regeneration of proteins into the necessary long-chain molecules has now been satisfactorily accomplished. Proteins consist of complex molecules built up from hundreds of simple units, the amino-acids. Some 28 different amino-acids are known to occur naturally and proteins differ from each other in the number, kind and arrangement of the amino-acid units. Many proteins, such as wool and silk, are visibly fibrous, while others, far from being fibres, can even be crystallized. This latter kind of protein is shown by X-ray analysis to possess folded chains, so that the molecule as a whole is "corpuscular" rather than fibrous. Such proteins become fibrous if the molecules can be "unwound" from balls into chains, and this straightening can be carried out by "denaturing" the proteins by treatment with alkali. When this fact was recognized the preparation of textiles by regeneration of proteins became a practical possibility.

For commercial development, however, two important conditions have to be fulfilled. In the first place a protein must be found which yields a fibre suitable for the textile trade, and secondly the raw protein must be obtainable in bulk without diverting valuable foodstuffs. In the past casein (from milk), edestin (from hemp seed), and zein (from maize) have been used as protein sources with varying success. British chemists have now found a satisfactory protein source in peanuts, or monkey nuts, which grow in large quantities throughout the British Empire, as well as in China and America. On pressing the nuts, about 50 per cent by weight of valuable arachis oil is obtained. From the residue the protein is extracted with alkali, precipitated and then made into a spinning solution. The latter is extruded through the fine holes of a spinnerette into a coagulating bath and fine filaments are obtained.

The resulting fibre, known as Ardil, is a cream-coloured, crimped, resilient fibre which is soft and warm to the touch and closely resembles wool. It dyes like wool and has the advantage of being unshrinkable and moth-proof. Ardil is not to be regarded merely as a substitute for wool—its main use is likely to be in combination with wool, cotton or rayon, enabling a new range of textiles to be manufactured.

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THE SURVIVAL OF TAENIA SAGINATA EGGS ON OPEN PASTURE

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Stockowners who conscientiously try to reduce the beef measle condemnation rate in their cattle have often inquired as to how long a pasture which has been contaminated with tapeworm eggs will remain infective to cattle.

Viljoen (1937) has remarked "It is accepted that moisture is the most important factor in viability of helminth ova. On the other hand it has not yet been established how long a pasture will remain infective with Tænia ova; what amount of drought *T. saginata* ova will withstand, and whether bovines can freely become infected when grazing on pasture under conditions of drought".

A series of small-scale experiments has been carried out at Kabete to try and give an answer to this question, which has a very practical bearing on pasture management.

Since Kabete is within the relatively high rainfall area of the Kenya Highlands producing a lush growth of Kikuyu grass in open pasture, a few parallel experiments were also carried out in the more dry conditions of the Rift Valley at Naivasha Government Farm, where the pasture is mainly short Cynodon grass. It was thought probable that the eggs might survive longer in the moister conditions at Kabete than in the more arid conditions of the Rift.

Small fenced-in paddocks were watered with suspensions of *Tænia saginata* eggs, obtained from worms collected either *post mortem* or from the Nairobi Sewage Works (an inspection of the grid-filters of the latter at any time of the year is a striking revelation of the prevalence of tapeworm infection amongst the human population of Nairobi who use the water-borne sewage system—quantities of tangled strobila of tapeworms and segments can be obtained here with the greatest of ease, not to mention innumerable Ascarids as well). A definite dosage of eggs per square yard was applied to each paddock. At the same time a measured sample of the eggs was administered *per os* to a measle-free calf, to determine the viability of the eggs at the time of infecting the pasture.

At varying periods after having infected the paddocks, calves which had been reared as far as possible under measle-free conditions were grazed thereon; these calves were then killed at a later date and minutely dissected for measle cysts.

Such experiments are, in theory, very simple to carry out, but for various reasons the results were not as satisfactory as they might have been. As has been found by other workers, the chief reason is the difficulty of producing a satisfactory infection, or any infection at all, in experimental animals dosed *per os* with egg suspensions. There seems to be no correlation between the number of eggs given, and the number of cysts found *post mortem*, which are usually only a fractional percentage of the total dose of eggs. It is probable that the maturation of the eggs is an important factor.

Secondly, the method of infecting the pasture is an unnatural one. In nature there is probably never a wide dispersal of eggs over a relatively large area, but rather a heavy concentration of eggs in a few square feet where an infected person has defecated.

Thirdly, wherever a labour force of Africans is congregated as at Kabete, in spite of regular treatment of these for tapeworm, any cattle associated with them seem to develop a natural measle infection with the greatest of ease—in striking contrast to the difficulty of producing an experimental infection. Breaking out and grazing of the experimental calves elsewhere has occurred in a few instances, and large scale measle experiments require the most rigid control, and isolation from all African contact if they are to be really satisfactory.

Lastly, since there is no known method of diagnosing infection in cattle before slaughter, it is necessary to use young calves which have been hand-reared and therefore are probably measle-free. This cannot be absolutely guaranteed, and there is always the possibility of pre-natal infection of the calves. Some animals used in these experiments were also taken from the "redwater" stables, in which they are kept from birth and never allowed out to graze. It was expected that such animals should also have been measle-free. Using such calves, or stall-fed animals, introduced another

difficulty in that they would not graze properly when turned into the infected paddocks, hence the period of grazing had to be much prolonged in some cases.

The table appended gives the results of the experiments. Bearing in mind the limitations noted above, these results at most indicate a probable survival of Tænia eggs on both types of pasture in an infective condition for about one year.

In view of the unsatisfactory correlation, in an experimental infection, between the very small number of cysts found and the dose, it is doubtful whether the actual numbers of cysts recovered are significant, and we feel that the presence or absence of any infection, however light, is a better criterion. Thus, though the results might indicate that the cyst infections were lighter on the more dry Naivasha pasture, we do not consider that this can be taken as showing that the eggs die more quickly under such drier conditions.

From the practical point of view, these results show that a paddock should be isolated for at least a year, preferably eighteen months, after contamination with infected human excreta, before it can be considered safe to graze cattle upon such pasture without risk of their becoming infected with measle cysts.

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SURVIVAL OF *TAENIA SAGINATA* EGGS ON INFECTED PADDOCKS.

Paddock No.	Date infected	No. of Eggs per sq. yard	Calf No.	Paddock Grazed		No. of days grazed	No. of days after infection paddock first grazed	Date calf killed	No. of measles found in carcass	Notes
				From	To					
Kabete 1	16-2-39 27-4-39	2,000	1	5-6-39	8-6-39	3	40	27-10-39	13	Grazed well.
Kabete 2	16-2-39 27-4-39	2,000	2	10-11-39	25-11-39	15	198	31-1-40	1	,, ,,
Kabete 3	16-2-39 24-4-39	2,000	3	26-4-40	8-5-40	14	364	17-8-40	1	,, ,,
Kabete B	19-6-44 11-7-44	3,400	4	24-7-44	1-8-44	8	13	6-12-44	0	Did not graze well first 3 days.
Kabete B	19-6-44 11-7-44	3,400	5	21-12-44	10-5-45	141	163	10-4-45	17	Calves about 1 month old, restalled every night. Plot grazed previously by Calf 4.
			6	21-12-44	10-5-45	141	163	10-5-45	9	
Kabete A	19-6-44 11-7-44	3,400	7	11-5-45	31-10-45	142	304	31-10-45	110	Calves about 1 month old.
			8	11-5-45	31-10-45	142	304	31-10-45	233	
Kabete C	19-6-44 11-7-44	3,400	9	11-5-45	1-11-45	143	304	1-11-45	9	Calves about 1 month old.
			10	11-5-45	1-11-45	143	304	1-11-45	26	
Naivasha B ..	6-7-44	4,000	11	29-8-44	2-9-44	5	54	7-2-45	15	Grazed well.
Naivasha A ..	6-7-44	4,000	12	3-5-45	19-5-44	17	301	22-6-45	5	,, ,,
Naivasha	6-7-44	4,000	13	23-8-45	12-11-45	81	413	16-11-45	1	Plot grazed previously by Calf 11.
			14	23-8-45	12-11-45	81	413	16-11-45	0	

CONTROLS.

KABETE :—

Calf A infected *per os* 44,000 eggs used for watering plot on 19th June, 1944. *Died 5th August, 1944,* 17 measles recovered.
Calf B infected *per os* 39,900 eggs used for watering plot on 19th June, 1944. *Died 7th July 1944,* 1 measle recovered.
Calf C infected *per os* 240,000 eggs used for watering plot on 11th July 1944. *Died 14th July, 1944,* 0 measle recovered.

NAIVASHA :—

As for Kabete plots A, B, C, same batches of eggs used for infecting both sets of paddocks

NOTES ON FODDER AND PASTURE GRASSES IN TANGANYIKA TERRITORY

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During the past few decades a large amount of work has been carried out in various parts of Africa in connexion with the propagation of indigenous and introduced fodder plants. Much progress has been made and valuable information obtained, but a great deal has also been learnt about the limitations set by an extremely variable range of soil types, topography and climate. Valuable introductions have been made, and, in areas with suitable climate and soil, certain species have been cultivated successfully. It is, however, becoming more evident that shortage of grazing and fodder supplies are not always due to lack of introductions of improved species, but is often caused through the absence of suitable systems for control and by lack of veld management. Such systems, and the degree of intensity to which they can be applied, depend upon a large number of factors, such as the productive capacity of the land, the branch of farming undertaken, type of management, control, transport, marketing facilities, and, last but not least, climate. Mixed farming has become a very widely-discussed topic, and knowledge regarding the value of grass for the protection and rejuvenation of agricultural soil as well as food for live stock has been greatly expanded. The pioneering work of Martin in Uganda and of others in connexion with the effect of grass roots on soil structure is revolutionary and is responsible for considerable modification in research programmes. Martin [2] writes: "In 1934 then, the main focus of the field experimental work in Uganda was changed from the manurial to the soil-structure aspect of the rotation and to possible combinations of the two." The usefulness of grass for pasture leys, conservation farming and anti-erosion work is rapidly becoming common knowledge, but the question as to the most suitable species and how they can be utilized to the best advantage still requires an answer. A number of fodder grasses suitable for soiling and ensilage, as well as some hay and pasture grasses including annual species, are briefly discussed in this paper. Succulent fodder grasses can generally only be recommended for growing on a relatively small scale, as they need intensive treatment with regular cultivation and adequate manuring.

Under most conditions mixed pastures have many advantages over those consisting of a single species only, except perhaps in moist Highland Kikuyu–Clover pasture areas. In the latter, intensive farming gives a high standard of control and makes possible the maintenance of a suitable sward. Mixed pastures do not only provide variation in taste and palatability, but the growth peaks of individual species vary to a large extent, thus prolonging the grazing period. Variation in growth habit of different species growing together often facilitates the formation of a better cover, thus giving more protection to the soil.

Both indigenous and exotic legumes form a very valuable group of fodder plants but they are not discussed in this paper, although reference is made to a few species.

Succulent Grasses for Soiling and Ensilage

Pennisetum purpureum (Elephant Grass, Napier Fodder).—A description of this grass and several other species discussed later was given by Staples in Annual Reports of the Department of Veterinary Science and Animal Husbandry [3].

Elephant grass is bulky and tall, often reaching a height of more than twenty feet. It is relished by stock during the early stages of growth when the stems are succulent, but on maturing they become coarse, fibrous and tough. When used for fodder, it should therefore not be allowed to grow taller than about four feet before being cut or grazed. On the whole this grass is best suited to cutting for fodder; if grazed it is liable to deteriorate quickly unless very carefully controlled. It is by no means an inferior fodder when used by itself in the young and succulent stage, but it could with advantage be mixed with legumes such as velvet beans or cow peas and with molasses in order to improve its quality and palatability, especially when ensiled. It can also be put to various other uses, such as making thatched barriers, wind breaks, planting along anti-erosion banks, mulch and compost.

Elephant grass generally grows in high rainfall areas or in moist fertile soil along water courses. Although it can be grown from seed,

roots and cuttings are most frequently used and give better results. Under natural conditions it is confined to regions of fairly low altitude, varying from sea level to about 4,500 feet, but it has been successfully cultivated at altitudes of over 6,000 feet. As a rule it does not grow well in large blocks except on fertile soil with adequate moisture; while under less favourable conditions the most satisfactory results may be expected when it is planted in belts, for example, on contour banks or along field boundaries.

Many varieties are hairy and difficult to handle, but glabrous forms practically free from hairs have been selected by a former Economic Botanist, Uganda. Such glabrous forms should be multiplied and distributed so that some of the less desirable ones can be replaced, especially where hand labour is used. Extreme variation in growth forms mainly due to varietal difference and habitat or treatment is very striking.

Setaria splendida (Millet Grass).—This is a glabrous, succulent, leafy grass which grows about five feet high. It is excellent for green fodder and ensilage and yields well under conditions of intensive cultivation. There are at least two distinct varieties, one of which is dark green and the other bluish-green. Several strains can be recognized from each of these. The former variety was first collected in Nyasaland and is now cultivated in many parts of the Union of South Africa and in Uganda. As it is difficult to raise from seed, roots have to be planted, The bluish-green variety, which seeds freely and propagates itself under natural conditions, grows along some of the watercourses in the Western Province of Tanganyika and in other parts of the territory. Both varieties are leafy, soft-stemmed, free from hairs and are very easy to handle. It would thrive in many parts of Tanganyika and would be an ideal fodder grass in areas with suitable climate and soil.

There are many other succulent species, for example *Panicum maximum*, which could also be used for green fodder and ensilage, but some are discussed under the heading of pasture and hay grasses.

Pasture and Hay Grasses

Cynodon plectostachyum (Star Grass).—This is one of the most valuable pasture grasses in semi-arid regions of East Africa and it has given exceptionally good results in parts of Central Tanganyika. In addition to providing good pasture it can also be turned into excellent quality hay and is a very useful species for anti-erosion work. There are many different forms, seven of which have been described by Staples [3]. There seems to be a certain amount of hybridization, and some forms resemble *Cynodon dactylon* so closely that it may be difficult to distinguish between the two species.

Star grass is a prostrate growing plant with long branching runners which root at the nodes. It cannot compete with tall, erect-growing species and is soon smothered by bunch grasses on land which is frequently burnt. Under favourable conditions it grows to a height of about four feet and thrives under grazing and mowing treatments provided these are properly managed. The best way to establish Star grass is to plant roots or cuttings of rooted runners, as seeds are difficult to procure and generally have a very low germination percentage.

Although the feeding value of *Cynodon plectostachyum* compares unfavourably with well managed pasture in England, and it has a further disadvantage in that its quality deteriorates on maturity when it becomes coarse and fibrous, French [1] found that young Star grass is rich in protein. He writes: "Comparison of the composition, digestibility and feeding values of the young sample of Star grass with those for green lucerne in flower . . . showed that the young Star grass had approximately the same feeding value as green lucerne. The more mature grass samples, however, were inferior to lucerne both in their digestible protein and starch equivalent values".

"The figures obtained for these Star grass samples agree with those reported from other parts of the world in showing how management controls feeding values. By keeping Star grass fairly closely grazed (never more than eight inches high) a much more nutritious feed is provided. As the grass gets over a foot in length its digestible protein and starch equivalent values decrease significantly. Because of climatic conditions, the growth of grasses over most of the Territory is very rapid and they quickly get beyond the stock and past their period of high feeding value. The result is that most stock graze either long green grass or mature dried grass and this explains the shortage of protein foods which is so characteristic of the stock diets in this Territory. By the conservation of grass whilst still in a young stage of development much could be done to overcome this protein shortage."

The extent to which management controls feeding values is of paramount significance and is an aspect very often not fully appreciated under African conditions. Furthermore, it is a factor which is very difficult to correct due to rapid growth during a short growing period with heavy irregular rainfall. There is, however, wide scope for improvement in this direction. A great deal of benefit can also be derived from the selection of leafy, palatable varieties, but on the whole we have not yet reached the stage where we can pick and choose, and we often have to utilize whatever species we can get to grow. The adoption of better systems of management will eliminate many difficulties and will simplify pasture establishment considerably. The problem should be considered on an ecological basis, since by creating conditions under which certain plants thrive other desirable species can often be encouraged to grow with relative ease. Unless the natural herbage can be more carefully managed, specially selected plants, often grown at great trouble and expense, will soon die out.

Cenchrus ciliaris (African Foxtail Grass).—This species produces a tufty growth 2 to 4 feet high. Many distinct varieties are recognizable, four of which were described by Staples [3]. More recently, Prentice has selected varieties suitable for propagation at Lubaga in the Lake Province of Tanganyika. *Cenchrus ciliaris* is well known for its drought resistance and grows well in the semi-arid parts of Central Tanganyika. It seeds freely with a high percentage of viable seed and is relatively easily established. Unfortunately, however, it does not form a dense cover when growing by itself. Both its palatability and nutritive qualities are good, it is relished by all types of stock, and it can be used both for grazing and hay.

Bothriochloa insculpta (Turf Grass).—This is a short, thin-stemmed, leafy perennial grass 2 to 3 feet high which often grows in pure stands on well-defined isolated areas in mixed grassland. It is also a valuable pasture and hay grass of semi-arid areas occurring over extensive regions of the Central and Lake Provinces. The high percentage of viable seeds produced enables it to be readily propagated under natural conditions. Some forms have a semi-prostrate growth habit which affords excellent protection to the soil. A great variation in growth form and habit makes it possible for several distinct types to be recognized. On the whole, *Bothriochloa insculpta* is a very desirable pasture species in mixed grassland.

Panicum maximum (Guinea Grass).—Guinea grass also varies greatly in size and form, and several varieties of this species were earlier described by Staples [3]. One of these is a very tall, leafy, light-green robust type growing to a height of about 15 feet, while a second type is 6 to 8 feet high, also leafy but rather dark-green with conspicuously long flower stalks and large seed heads. These are both heavy yielding fodder grasses but they are rather hairy, particularly around the nodes, and are not easy to handle. Another very distinct type is a small grass about 3 feet high bearing bluish or purple seed heads. There are also various other intermediate forms.

Guinea grass, particularly its tall robust growing varieties, tends to become very stalky and fibrous on maturing, but it is a palatable grass relished by stock, especially during the early stages of growth. It cannot, however, tolerate continuous cutting or heavy grazing, and when submitted to these treatments it is soon replaced by other grasses. This grass is remarkably tolerant to burning and thrives in areas which are periodically subjected to fierce fires. It is regarded as an indicator of high soil fertility, and in less fertile parts seems to give way to *Hyparrhenia dissoluta* and other similar species. It seeds freely and is easily propagated from seed, though the flower heads of some varieties are often attacked and destroyed by a smut fungus. Generally speaking, *Panicum maximum* is a grass of low rainfall regions but it attains its best growth along watercourses and fertile valley bottoms.

Chloris gayana (Rhodes Grass).—This is a useful pasture and hay grass about 3 feet high and semi-prostrate in habit. It grows under a fairly wide range of conditions but requires a soil with a rather high moisture content. Rhodes grass has a high percentage of viable seeds and is an excellent grass for short-term leys. It is often sown together with *Paspalum dilatatum,* Golden Crown Grass, in mixed pastures, but the latter only thrives under a limited range of soil and moisture conditions. Rhodes grass is one of the few species of pasture grasses of which seed has been produced commercially.

There are many other valuable pasture grasses which commonly occur as constituents of various plant communities in different parts of the Territory. The more important of these are best discussed in groups classified according to their respective environments.

Perennial Species of Different Grassland Types

These grasses occur in various regions including the sandy and clay soils of "Miombo" vegetation, the large grassy plains along the Serengetti, the mixed woodland formations and some of the Highland grasslands. They occur in well-defined communities or as is more often the case, mixed with other species in irregular pattern. They are all useful constituents of mixed grassland and would yield valuable pasturage under proper systems of management. This group includes species such as:—

Andropogon schirensis.
Brachiaria brizantha (Palisade Grass).
Brachiaria dictyoneura (Sheep Grass).
Chrysochloa orientalis.
Digitaria eriantha (Finger Grass).
Digitaria milanjiana (Finger Grass).
Digitaria setivalva (Finger Grass).
Sporobolus fimbriatus.
Themeda triandra (Red Oat Grass).
Trachypogon plumosus (Grey Tussock Grass).

In some of the drier parts, *Pennisetum mezianum*, *P. straminium* and *Sporobolus helvolus* form important local dominants.

Annual Grasses Common in Semi-arid Areas

Pastures in heavily grazed parts of the semi-arid regions of the territory consist of annual grasses to a very large extent. Under present conditions they form an important part of the grazing but they have certain disadvantages. Though these species grow rapidly during the wet season, they die shortly after the rains and leave the soil surface exposed. Furthermore, no dry season grazing remains for the stock. We should therefore endeavour to replace these grasses by perennials which would give better protection to the soil and provide grazing throughout the year. The most common amongst these annual pasture grasses are:—

Brachiaria serrifolia.
Chloris pycnothrix.
Chloris virgata.
Dactyloctenium ægyptium.
Digitaria velutina (Syn. *D. horizontalis*).
Eleusine indica.
Eragrostis aspera.
Gilgiochloa indurata.
Rottboellia exaltata.
Urochloa trichopus.

Other grasses which come in after cultivation and which are particularly noticeable on sandy soil in "Miombo" woodland areas are *Hyparrhenia dissoluta*, *H. filipendula*, *H. rufa*, *Heteropogon contortus*, *Pennisetum polystachyon* and *Rhynchelytrum repens.*

Swamp-Edge Grasses and Species Occurring in Moist Highland Areas

Some of the swamp grasses provide very valuable dry-season grazing as they remain green long after the rest of the pastures have dried off. Some of the more important species belonging to this group are:—

Echinochloa pyramidalis (Antelope Grass).
Ischaemum brachyatherum.
Leersia hexandra.
Panicum coloratum.
Panicum meyerianum.
Panicum repens.
Paspalum auriculatum.
Setaria holstii.
Setaria sphacelata.

Acroceras macrum, *Digitaria scalarum* and *Pennisetum clandestinum* (Kikuyu grass) are typically high altitude species. The latter is an important pasture grass and can form a dense sward either by itself or mixed with clover. However, Kikuyu grass can only be propagated from roots and it requires a fertile soil and high rainfall.

Bromus runssoroensis and *Panicum trichocladum* are typical forest-edge species and grow vigorously in their natural habitat, but they cannot survive under adverse conditions.

Exotic Pasture Grasses

A large number of pasture grasses have been introduced for trial in the past but on the whole these have not proved successful. *Bromus marginatus* and *Paspalum dilatatum* have given good results in some of the moist Highland areas, but scope for their development is rather restricted as they only thrive under a limited margin enjoying favourable conditions. *Digitaria poleevansii*, *Digitaria pentzii* and other species have given promising results in some of the dry areas, but again there is not much scope for extension as they have to be propagated from roots.

There are many other species which could be used with advantage, although individually they are of little significance or fall within the same general categories as those already described.

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THE MISUKU LAND USAGE SCHEME, NYASALAND, 1938–1947*

By D. N. Smalley, M.B.E., Senior Agricultural Assistant, Nyasaland

(*Received for publication on 25th November, 1947*)

Topographical

The Misuku Land Usage Scheme embraces some 500 square miles of mountainous country lying to the north-west of Karonga and some 40 miles from Lake Nyasa. The area is bounded by the Songwe River and Tanganyika on its northern boundary. Some of the mountains attain a height of 6,000–7,000 ft., and the whole area abounds with deep rugged watercourses. Small patches of evergreen forest still survive on three of the high mountain tops, and the whole area was well wooded and watered when first penetrated by the Asukwa people some years ago.

Up to 1937 comparatively little interest was taken in the Misuku regions as prior to then most of the land was owned by the British South Africa Company and nominally managed by a local agent resident in Karonga. On the handing over of this area to the Nyasaland Government in 1937 by the British South Africa Company, it was decided that a detailed report upon it should be compiled. The report submitted made bad reading, the acute distress of the Asukwa people, chronic soil erosion, wanton wastage of natural resources and a general most distressing state of affairs was disclosed.

It was at first thought that it would be necessary to evacuate the whole of the resident population in the Misuku Hills, and to re-establish them in some more productive areas. The writer pointed out that had this measure been adopted it would be only a matter of time before a second area would have to be evacuated by the primitive and untutored Asukwa peoples. It was obvious that instruction in simple and practical agriculture and land usage was their first need. They had, I contended, already shown their ability in shifting agricultural methods, and in their nomadic traits. This advice was accepted, and to the writer fell the task of a survey of the distressed areas, and the submission of plans for restoration.

The People

The Asukwa people sprang from the Ngambe tribe originally occupying the hilly areas around Tukuyu in Tanganyika. Both the parent tribe and its neighbours were nomadic primitive peoples existing to a great extent upon wild fruits, berries, and roots. Not until fairly recent times did agriculture in any recognizable form play an important role in the lives of the Asukwa people. As the depredations into wild fruit bearing areas intensified, often at the expense of the trees themselves, the necessity for new habitable areas where food abounded became imperative. Necessity thus drove these people across the Tanganyika borders into the well wooded country in Northern Nyasaland. When the Asukwa became finally settled in these parts the area became known as the Misuku country. The people up to 1937 showed little inclination towards settling, and roamed over a wide area of this remote hill country.

It was soon evident to the Asukwa that other means of food raising than the collecting of wild roots, fruits and berries, would become necessary to support their growing numbers. Finger millet grown after the felling of trees and heavy burning established itself as a moderately easy way of wresting extra food from the land with the minimum of effort to the cultivator. As timber supplies were burned up in this manner, settlements, which often could hardly be called villages, were compelled to find new forests to massacre. Thus in a comparatively few years was a once well-wooded and watered land denuded and reduced to the deplorable state it was taken over in in 1937.

To add to the difficulties of the people, and accelerating the widespread destruction and erosion was the acquisition of considerable numbers of cattle, sheep and goats. Too often these were driven into the rapidly drying river beds, causing heavy damage and gully erosion. So difficult had the lives of the Misuku people become that the fit male population spent the bulk of its time searching for food outside, or working for scanty food supplies with their prosperous neighbours on the lake shore around Karonga.

* A fuller account of the Misuku Land Usage Scheme was prepared in 1943 and is filed in the Department of Agriculture, Zomba, Nyasaland. This article summarizes the work to date.

The Problem

It will already be apparent that difficult problems had to be solved. The Asukwa people, numbering some 3,500–4,000, with their cattle (some 4,000 by this time) had little desire, and certainly no intention of learning a way of life suited to the hill country into which they had penetrated and settled. A meeting under the chairmanship of the District Commissioner was called with a view to handling the situation on the advice of the Veterinary, Forestry, and Agricultural Officers responsible for the Misuku areas.

The outcome of this meeting was that to the writer fell the job of preparing "an appreciation of the situation". This investigation, occupying some six months and involving a village by village survey, disclosed that some formidable tasks had to be undertaken. For clarity of presentation, a summary of some of the more important items is given below under departmental headings.

Forestry

1. Preservation of the rapidly dwindling evergreen forests and the establishment of forest reserves.
2. Building up a sufficient domestic timber supply throughout the area.
3. Establishment of Village Forest Areas.
4. Protection of stream and river banks by introduction of protective vegetation.
5. Control of bush fires.
6. Establishment of quick growing building materials such as bamboo, to prevent unwarranted inroads into existing scanty timber supplies.
7. The prohibition of burning in gardens for millet growing.

Agricultural

1. Soil conservation measures to be introduced throughout the area.
2. The prohibition of flat planting on steep hill slopes.
3. Strip cropping to be introduced.
4. Prohibition of millet growing except under strict supervision and in protected contoured gardens.
5. Introduction of crop rotations and a better balanced diet.
6. Shifting agriculture to be stopped and soil anchorage obtained.
7. Land-rest to be imposed, and proper use to be made of valley bottoms for food production in the dry season.
8. The prohibition of unchecked downhill gardens in river beds and along stream banks.

Veterinary

1. Controlled cattle grazing to be established.
2. Prohibition of grazing cattle in stream beds.
3. Rotational grazing areas to be demarcated and used.
4. Cattle to be segregated from dwellings and kraalled separately.
5. Watering points to be demarcated and their proper use enforced.
6. The use of cattle manures in gardens to be demonstrated and encouraged.
7. General animal husbandry to be improved.

Thus, briefly stated are some of the major tasks which confronted the Misuku people and those responsible for their welfare.

The Scheme in Operation

First Stage.

First a large clay model was made outside the Misuku Court House. Considerable care was taken in its construction to ensure that the model resembled the completed task on the land as it should appear about five years hence. Meetings and talks around the model were held at frequent intervals but it is now frankly admitted that the model was treated as a joke by the local people, and before the first year ended had become the toy of the Misuku children. Although for some time the Asukwa showed complete disinterest in, and appeared unimpressed by, this exhibit, nevertheless most of the population had viewed the model before its final disintegration. Many agriculturalists later admitted they had gained a good idea of what was intended, and expected from them, when they set about the task of restoring their own devastated lands.

Next came a period of intense village by village propaganda. Lectures, demonstrations, and meetings were held continuously throughout the whole of the Misuku Land Usage area, and the reactions of each locality were carefully noted. At the end of six months hard unremitting work the general progress made and situation can be summarized as follows. Complete indifference to and interest in the new teachings, in fact the general impression of the local residents was that this was but a new form of "European Madness", and would no doubt soon blow over.

At about this time a centrally sited demonstration plot in the heart of the Misuku country was opened for the growing of coffee and food crops, and for large scale practical demonstration of the new field technique.

The first year's work ended with little to show beyond a Government controlled demonstration centre, a rather disillusioned demonstration staff, and a more or less truculent resident population, and the job in hand scarcely begun.

Second Stage.

It was felt by this time that ample general demonstration work had been undertaken, admittedly with little outward success so far, and that a phase of individual instruction to willing co-operators with the Scheme should begin.

Instructors and demonstrators were grouped and allocated a definite sphere of influence, usually consisting of a group of two or three villages suitably sited. The owner of a food garden actively co-operated and assisted the staff in the restoration of his lands. It was not long under this system before dozens of gardens, and considerable stretches of stream bank began to take shape along planned lines.

By the end of the second year many of these assisted agriculturalists had obtained a considerable increase in crop yield, and thus proved the efficacy of the new teachings. These co-operators did not hesitate to voice their successes and thus a new medium of propaganda was created.

Most of those early efforts would to-day, even by the Misuku people, be classed as a "complete headache". What really mattered in this early stage was that the ice had been broken, and a practical start by the people themselves had begun. Contour bunds and drains were in some places to be seen running at jaunty angles down impossibly steep hill slopes. Such "headaches" were really a godsend, as their defects very soon showed up in the rains and the culprits needed no inducements to carry out effective corrective measures.

It had been obvious from the commencement of the Misuku Scheme that no success in restoration was possible so long as cattle were permitted to roam at large, and uncontrolled bush burning tolerated. These two difficult measures were early tackled with vigour. All cattle were removed from the heart of the main residential and agricultural areas to well sited communal kraals under a supervised rotational grazing system. All bush burning was strictly forbidden for a period of three years so as to enable the scanty grasses to multiply. Both these extremely unpopular decisions, in so far as the Asukwa people were concerned have paid handsome dividends, and have been fully vindicated.

Third Stage.

During the third year the majority of the Asukwa people were mildly convinced that the Misuku Land Usage Scheme offered an improvement upon the old state of affairs. The general picture over the whole area showed a distinctly new outline, and in some places detailed improvements were becoming plainly visible. It was obvious even to the casual observer by the end of the third year that the main opposition of the people had been overcome, and it now remained only to consolidate and complete the many details of the scheme. It was also at this time that many hundreds of Misuku residents who had sought refuge in Tanganyika and Northern Rhodesia, during the earlier stages of the Scheme, rather than face up to their difficulties, began to take up residence again, often in a shame-faced manner.

Fourth Stage.

No Misuku resident could by this time plead ignorance of the teachings of the Land Usage Scheme. Many well-managed contour-ridged and contour-stripped food gardens, under full protection against erosion, were to be seen throughout the area. It was now thought desirable to ask for compulsion in agricultural, forestry, and veterinary matters, to be applied to the Land Usage Area. To this the Native Authority readily assented.

There were of course still a few stubborn opponents to the new teachings but these were successfully dealt with under the new measures of compulsion. As the imposition of fines proved ineffective it was decided to present defaulters to the Scheme with a *fait accompli*. The cost of labour engaged by the Government in rectifying errors and omissions in defaulters gardens was paid by the defaulter through the Native Courts. It was soon realized that further opposition was useless, and the last few laggards had to submit to the new teachings.

By the end of the fourth year even the local inhabitants were admitting that their lands were now somewhat resembling the once despised, and almost forgotten clay model that graced the front of the Misuku Court House in 1938.

Fifth Stage.

There is little new to add regarding the fifth and subsequent years. Steady consolidation and improvement has continued and is at present being maintained in a reasonably satisfactory

manner. The new technique has been mastered and is now acclaimed by the people themselves, and for the first time in their history they find themselves with an abundant food supply and reasonable surpluses for sale through local markets. Even as early as 1943 some 70 tons of beans were offered for sale by the Misuku people as surplus to their own food requirements. By the end of the fifth year it was felt that it was no longer necessary to retain the Instructional and Demonstrational staff and that the Scheme could be put on a maintainance basis. This was done by the employment of four Soil Conservation Rangers whose duty it still is to ensure that there is no backsliding and reversion to the bad ways of the past.

Review

It is now possible after some ten years to judge better the attainments of the Misuku Land Usage Scheme.

It is still quite obvious from the number of cases dealt with through Native Courts for infringements of the Misuku Land Usage Scheme Rules that strict control will have to be maintained over the area for some years further. It is by no means to be assumed that after ten years' careful management the teachings of the Misuku Scheme could be termed ingrained, habitual, and freely accepted by the Asukwa people.

Earlier on in this account some of the tasks undertaken were classified under departmental headings for clarity of presentation. Likewise in reviewing results obtained will the same style be used. It must, however, be stressed that at no period in the Misuku Scheme has any attempt been made to segregate departmental tasks. It was found possible to undertake forestry and agricultural, or veterinary tasks simultaneously. The whole scheme was based on integration, and not segregation of departmental issues. Team work was aimed at, and supplied the answers to the many difficult obstacles to be overcome.

Forestry Attainments

Thriving Village Forest Areas now established.

An abundant supply of bamboo in villages, and along streambanks. This material is now mainly used for hut building in preference to poles. Some 2,000 miles of stream banks have been fully planted with protective vegetation. (Banana, bamboo, elephant grass, sugarcane). Control of bush burning has been established. (In some villages it has been found difficult to get the people to burn at all as they so greatly value their restored grasslands).

The evergreen forests have now been declared State reserves and are fully protected.

Veterinary Matters

Cattle have assumed a more balanced and reasonable place in the economy of the locality.

The health and appearance of all animals has changed out of recognition but much can still be done to improve animal husbandry. Animals are now housed in separate kraals and no longer live with the people.

A better dispersion of cattle over the whole area has been attained. Some use is now being made of manure for agricultural purposes. Animals water at fixed places and do not roam in stream beds.

Agricultural Matters

Soil anchorage has been attained over 500–600 square miles of difficult country and anti-erosion measures are spreading to neighbouring areas. Soil erosion has been almost halted.

A well balanced ample food supply has been established with surplus food available for sale in local markets.

Millet growing has been reduced to reasonable proportions and is grown under supervised conditions only.

The people have settled in the restored areas and show little or no tendency to engage in shifting agriculture. The practice is almost forgotten.

A substantial food reserve has been created from the large scale banana plantings along stream and river banks.

Rivers and streams now run crystal clear throughout the year and an abundant supply of good water is available throughout the Misuku area. Streams that had been dried up during the lifetime of many of the inhabitants are now giving good supplies all year round.

Grasses throughout the area have been restored for thatching and grazing purposes.

A new era of agricultural prosperity has been made possible for the Asukwa people.

Acknowledgment

The success of the Misuka scheme depended entirely on team work, and I wish to acknowledge the assistance and encouragement given by my official colleagues, by the Native Authorities, and, latterly, by the African peasants themselves.

THE CONTROL OF DOG TICKS WITH GAMMEXANE AND GAMATOX

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Gammexane

The three major diseases of dogs in East Africa are distemper, which is a virus disease, tick fever, and rickettsia, both of which are tick-borne. The control and prevention of distemper can be achieved with considerable success by means of vaccines and hyper-immune serum, although these have been unobtainable during the war years. Tick fever and rickettsia are both susceptible to treatment if commenced early enough, but the only means of prevention are the control and destruction of ticks which carry the disease.

The past few years have seen rapid advances in the production of efficient insecticides, the best known being D.D.T. which is highly lethal to such insects as flies and fleas. Its action against ticks, however, has been disappointing. More recently another insecticide known as benzene hexachloride (gammexane or 666), with the formula $C_6H_6Cl_6$, has been synthesized and is now being produced on a commercial scale. It possesses marked advantages over D.D.T. in several respects, particularly in its action on ticks.

The discovery of gammexane was announced two years ago by Slade [1] and other workers. Steward [2, 3] confirmed that it had marked lethal properties in very high dilutions on flies, fleas, mites, lice and ticks and that it had considerable residual activity, lasting in many cases for several weeks. He found that a single application of the pure product (the gamma isomer of benzene hydrochloride) was highly effective against the pig louse (*Haematopinus suis*) when diluted 1:20,000; against biting and sucking lice of dogs (*Trichodectes canis* and *Linognathus setosus*) when diluted 1:40,000; and against fleas (*Siphonaptera*) when diluted 1:15,000.

It has already been established that gammexane is effective against several types of ticks and mites. Hocking [4] found that the eradication of the human tick *Ornithodorus moubata*, which carries relapsing fever in East Africa, from barrack huts could be achieved by spraying the soil with a solution of gammexane. Taylor [5] cured mange in rats with two applications of 0.1 per cent gammexane in liquid paraffin. Lewis [6] treated 37 cases of canine sarcoptic mange successfully with a proprietary preparation containing gammexane, and Steward [2, 3] reports favourable results with an emulsion containing 0.008 per cent gammexane against the blue tick (*Boophilus decoratus*). The writer has found that the fowl tick (*Argas persicus*) can be killed on the host by immersion in a solution containing 0.005 per cent gammexane. Bekker and Graf [7] found that the arsenic-resistant blue tick in South Africa could be successfully controlled by regular immersions of cattle in dips containing gammexane emulsions, with or without a proportion of arsenic which, these authors suggest, may help to prevent decomposition and loss of efficiency of the gammexane. The chief advantages of gammexane compared with arsenical preparations are its activity in high dilutions, its longer residual effect, and the fact that it is non-poisonous.

Reports on the use of gammexane on dogs and cats are scarce, particularly with regard to the possibility of undesirable toxic effects. A disadvantage in the use of D.D.T. on these animals has been the occasional manifestation of toxic symptoms, especially with cats because of their propensity for fur-licking. Buxton [8] in a comprehensive review of D.D.T. and its properties, concludes that for all practical purposes its use involves neither man nor animal in any danger, but more recently the experiences of several veterinarians (Kirk [9], Wain [10], Neve [11] and King [12]) have shown that this insecticide must be used with care, and in carefully computed dilutions and that occasionally animals appear to portray individual hyper-sensitive idiosyncrasies. It is important to know, therefore, whether gammexane may posses similar undesirable properties when used on dogs and cats, since it seems likely that it will largely replace D.D.T. in the control of dog ticks. Recently, the writer was afforded an excellent opportunity to observe the effects of regular applications of gammexane on dogs in kennels at Kabete.

Some months ago, an outbreak of *rickettsia canis* occurred amongst dogs at the laboratory. This disease is carried by ticks and is characterized usually by fever, inappetance, vomiting, diarrhoea and, in the later stages, by swollen glands. Carmichael [13] showed that *Rhipicephalus sanguineus*, the brown dog tick, is one of the vectors, by infecting dogs with

emulsions of this tick. It is probable that *Haemaphysalis leachi*, the other common dog tick, is also a vector. Blood smears reveal the presence of rickettsia bodies in the large lymphocytes. It was known that the rickettsia parasite is susceptible to sulphapyridine (M & B 693) (Carmichael and Fiennes [14]) and prompt treatment with this drug resulted in cures in every case, but it was noticed that whenever another susceptible dog was introduced into one of the kennels which previously had housed an infected dog, the new entrant invariably became infected in seven to ten days, and it was evident that ticks carrying the parasite were firmly established in and around the kennels. It was decided, therefore, to attempt to eliminate the disease by the destruction of the vectors, and to accomplish this by the systematic application of gammexane to the hosts.

A stock solution containing 1 per cent gammexane in toluol was prepared. This was diluted 150 times in water before use, giving a final concentration of gammexane of 1 : 15,000. Two dogs were thoroughly bathed with the solution on two occasions with a week's interval between. The dogs were kept under careful observation and since no signs of toxicity or skin irritation occurred, all the other dogs, 20 in number, were similarly treated. About two gallons of the diluted insecticide were prepared and placed in a bath in which the dogs stood whilst the solution was ladled over them until their skins were thoroughly wet. The head was not neglected but care was taken to protect the eyes. Bathing was continued at intervals of ten to fourteen days and some of the dogs received as many as 12 baths. On only one occasion did anything occur for which the gammexane might possibly have been responsible. A smooth-haired Dachshund, after the 4th application, developed a skin rash on the chest which rapidly developed into numerous small blebs or pustules yielding greenish-yellow pus when expressed. Bacteriological examinations revealed that the pus was composed of staphylococci in pure culture. The pustules were all squeezed open, washed and treated with penicillin, which resulted in rapid healing. At no time did the dog show a systemic disturbance or any other signs of illness. Since no other dog showed a similar skin irritation, it is not possible to say whether or not the gammexane was responsible, but it was decided thereafter to dilute the stock solution 200 times instead of 150 times, giving a final concentration of gammexane of 1:20,000 or 0.005 per cent, and following this modification no other untoward results occurred.

Meanwhile, the effect of regular bathing in gammexane on the disease itself was remarkable. After the first few applications no new entrants to the kennels became infected, and as dogs already infected gradually yielded to treatment, the disease disappeared. Since that time no further cases have occurred. The effect on the ticks themselves was also highly satisfactory. Ticks were not killed immediately but commenced dropping off a few hours after bathing and 24 hours later they had disappeared completely. A careful watch was kept on one or two selected cases and it appeared that the residual effect of the gammexane lasted for about a week, after which ticks began to reappear.

Gamatox No. 2 Paste*

Whilst the investigations detailed above were proceeding, a small supply of Gamatox No. 2 paste was obtained. This is a proprietary product, containing 5 per cent gammexane, in the form of a thick paste which breaks down readily in water. The recommended dilution for cattle dips is 1 : 1,000, giving a final percentage of 0.005 per cent gammexane. Since this is the same percentage of gammexane as was sued in the earlier trials, it was decided to try the effect of treating the dogs with Gamatox in this dilution.

Preliminary trials were carried out using four smooth-coated mongrel dogs of medium size. The dogs were thoroughly wetted as before by standing them in a bath and ladling the mixture over them. No ill effects whatever were observed. A week later the treatment was repeated using double the strength of gamatox. Again the dogs remained perfectly healthy. It so happened that at this time one of the dogs had a large, open cut in the right shoulder and it was interesting to note that the affected area suffered no ill effects and healing was in no way retarded.

A large tank was now constructed capable of holding about 50 gallons of fluid. This was filled with gamatox diluted to 1 : 1,000 and the four dogs totally immersed with the exception of eyes and nose. This treatment was repeated at weekly intervals until it became quite apparent that the dogs were not being adversely affected. All the other dogs were now dipped in the same way and this procedure has been

* Messrs. Cooper and Nephews, South Africa (Pty.), Ltd.

maintained ever since at seven to ten day intervals. Gamatox has destroyed and controlled ticks and prevented the reintroduction of tick-borne diseases in a manner equally satisfactory to pure gammexane solution. It should be added, however, that it has been found that unless the solution is renewed about every three weeks, its potency appears to diminish. A similar diminution in insecticidal activity has been noted by persons using Gamatox in cattle dips.

SUMMARY

Gammexane and Gamatox No. 2 paste, have been shown to destroy and control dog ticks satisfactorily by dipping the hosts every seven to ten days in dilutions containing a final concentration of 0.006 per cent gammexane. No adverse effects were observed in dogs so treated.

ACKNOWLEDGMENTS

I wish to thank Dr. Worsley, Central Veterinary Research Institute, for preparing the gammexane solution used in the first trial, and Messrs. Cooper and Nephews, S.A. (Pty.) Ltd., for supplying the Gamatox No. 2 paste. I also wish to thank the Director of Veterinary Services, Kenya, for permission to publish this article.

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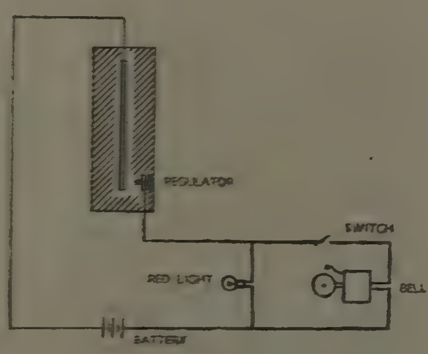
AN ALARM FOR PYRETHRUM AND PAPAIN DRIERS

The accompanying sketch shows a small apparatus which was designed at the request of various firms. It is a device which rings a bell when a certain temperature is exceeded and can be used to warn managers some distance away when their staff are overstoking the drier.

The regulator can be adjusted to alter the temperature at which the bell will ring and if necessary this variable can be enclosed in a locked box. The bimetallic strip bends when the temperature is raised, and eventually when the temperature is high enough it closes the circuit thus operating the bell and red light. The bell can be switched off, but the red light remains on until the temperature falls below the selected maximum.

Messrs. Twentsche Overseas Trading Co., Ltd., Dar es Salaam, have quoted for the supply of the above (without battery) at Sh. 95.



Chemical Laboratory,
Dar es Salaam.
25th October, 1947
W. D. RAYMOND

THE LIFE OF PERENNIAL CROPS

By G. B. Masefield, M.A., A.I.C.T.A., Agricultural Officer, Uganda

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The length of life to be expected of many tropical crop plants, or even their economic or payable life, are subjects on which agricultural science is still remarkably ignorant. This may be due partly to the short time in which agricultural scientists have been working in the tropics, and to lack of continuity on research stations and plantations, where the life of a crop plant may often be longer than one European's working life. The object of this paper is to draw attention to our ignorance, rather than our knowledge, of the subject, and to emphasize its importance for formulating agricultural policies in East Africa.

As an example of the present state of our knowledge, I append a table showing the most useful remarks on the life-period of various crops which with some diligence I have succeeded in unearthing from a large number of text-books and monographs. Its inadequacy will at once be apparent: there are several important crops on which apparently no author has cared to commit himself, some of the observations are very vague, many of them are phrased so as not to be comparable for any two crops.

Banana.—At least 20 years economic bearing.

Castor Trees.—Continue cropping up to 9 years old.

Cho-cho (Sechium edule).—Economic life 20 years and more.

Citrus Trees.—Economic life about 40 years.

Coco-nut Palms.—Life up to 80 years.

Arabica Coffee.—Average life about 30 years.

Robusta Coffee.—Can live to well over 100 years.

Date Palms.—Cease fruiting at 75 to 100 years.

Manila Hemp.—Life 15 to 20 years.

New Zealand Flax.—Life "apparently indefinite".

Oil Palm.—Economic life perhaps 50 years.

Oyster Nut.—Economic life 25 years or more.

Passion Fruit.—Life 5 to 6 years.

Pawpaw.—Life 4 to 5 years.

Pepper.—Economic life 25 to 30 years.

Pigeon Pea.—Life up to 5 years.

Pineapple.—Economic life 6 to 13 years according to variety.

Pyrethrum.—Yield begins to drop after fifth year.

Para Rubber.—Economic life about 35 years.

Ceara Rubber.—Exhausted and best replaced after 6 years.

Tea.—Economic life over 50 years.

Tung Trees.—Maximum production continues up to about 50 years.

It is admittedly difficult to make a useful statement for any crop, since the number of years for which life may actually linger on in a senile tree is not of much practical interest, while "economic life" is a very vague term—for yields that can be considered "economic" will vary with current prices, in addition to the variation in yield of trees of the same age due to differences of soil, climate, etc. Yet accurate surveys could greatly increase our knowledge, as has been shown by Professor Shephard's investigations on the caçao crop of Trinidad [1], which on this subject may be summed up as showing that:—

(*a*) The yield of cacao is highest from trees of 15 to 25 years old.

(*b*) At 25 to 45 years, yield falls and cost of production rises.

(*c*) After 45 years, yield remains fairly steady but cost of production still rises.

Coffee

Coffee is perhaps the crop in which we are most concerned with problems of this kind in East Africa. To exemplify the problem, a case occurred in my experience in which an experiment on different treatments of Arabica coffee was wound up after some 10 years on the grounds that it had already given all the information it was capable of giving. This may have been true; but is it safe to assume that the reaction of coffee to different pruning or cultivation methods would necessarily be the same in the second, third, or fourth decades of its life as in the first?

Certainly in the case of cultivation treatments this would not be true. A common type of experiment on coffee is that in which clean weeding is compared with treatments such as mulching, cover-cropping, or a light weed cover periodically dug in. It is a frequent experience that the clean-weeded plots give the highest yield in the early years but that some of the other treatments may catch up later and give higher yields—often towards the end of the first or in the second decade of the crop's life. The cumulative total yields over the years of two such contrasting treatments often form curves which intersect at some point in the life

of the crop; but, as has been well pointed out by Braconnier [2], the age at which they intersect may depend on such factors as the original structure of the soil, the degree of slope, or the measures taken to avoid soil erosion. The agronomist cannot really advise the grower as to which of such cultivation treatments it will pay him to adopt until he knows to what age it is intended to grow the crop; and this is a question which neither grower nor agronomist can answer on present knowledge.

Neither are varietal differences consistent at different ages of the crop. Uganda planters long ago found out that whereas the "Bourbon" variety of Arabica coffee outyields "Nyasaland" in its earlier years, the latter overtakes it before long and is therefore the better variety to plant in the long run. Similarly with Robusta coffee in Uganda, the erect Robusta types often yield more heavily than "Nganda" at first, but the latter catches up later and is a more sustained yielder, and is now considered generally better to plant. On prospects of a falling market, however, might not a shrewd planter consider it would pay him better to plant a quick-yielding variety for a bigger early return?

Another consideration is that treatments may actually affect the length of life of the crop. For example, in the pruning experiment quoted above, is it inconceivable that one pruning treatment might prolong the life of the trees more than another, and that, if the experiment had been carried through to the end, the difference in total cumulative yields might have been sufficient to swing the balance in favour of that treatment irrespective of yields in earlier years? The provision of shade is another factor which might very well influence the life of the crop.

The general advice of the Uganda Department of Agriculture at present is that Arabica coffee grown by peasant farmers should be uprooted and replaced at from 10 to 30 years old according to how well it has been looked after; and this recommendation is being put into practice in Bugishu by a large replacement programme fed by seedlings from Government nurseries.

With Robusta coffee, probably no one in Uganda would care to commit himself to a more definite statement than that its economic life is considerably longer than for Arabica. Trees of the local "Nganda" type have been known to be still bearing crops at well over 100 years old, but it is impossible to judge their degree of senility when no records exist of the size of crop they bore in earlier years. Such questions can only be answered by long-term observations on experimental plots, with careful records of yield and labour costings.

Plantains

Useful knowledge can also be obtained by surveys of existing crops. In a previous paper [3] I have quoted records which show that while plantain gardens as much as 60 years old can be found still in cultivation in Buganda, in many villages the oldest that can be found vary from 32 to 45 years—indicating presumably that in the experience of growers this is nearer the limit of useful life. There are also indications that labour costs on the maintenance of a plantain garden in Buganda tend to increase after its early years. With this crop again the choice has to be made between varieties which give the heaviest annual yield and those with the longest lives, and a proper decision cannot be made without a knowledge of the period of cultivation expected.

Para Rubber

If it is true that the economic life of Para rubber is in the region of 35 years, some of the plantations in East Africa must now be becoming senescent, and it would be interesting to know if plantation records of yield bear this out. It seems probable, however, that climatic differences would affect the life of the crop as much as they do its early growth; for example in Uganda, where the climate is by no means ideal for rubber, tapping is not begun till 7 years old as against 4–5 years in Malaya or even a few hundred miles away in the Belgian Congo.

The whole subject of the life of perennial crops requires much more information, and it is most desirable that further study should be undertaken under local conditions on those crops which are of concern to East Africa. Related to it is another series of problems which also require to be assessed in terms of production and labour costs, namely the optimum length of life of plant associations such as leys and "permanent" pastures.

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A NOTE ON THE POSSIBILITY OF THE STABILIZATION OF PYRETHRUM

By W. D. Raymond, Ph.D., B.Sc. (Lond.), F.R.I.C., and V. P. Padhye, M.Sc. (Benares),
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(*Received for publication on 27th October, 1947*)

Following work [1] on the stabilizing effect of sulphur dioxide on papain, our attention was drawn to a paper by Mario Covello [2] on the inactivation of the oxidases in pyrethrum flowers with the resultant stabilization of the dried product. Covello's work was carried out on flowers in different stages of development and by different methods of drying. The development stages were:—

(1) the closed flower heads,
(2) the heads just opened,
(3) the head completely opened,
(4) more matured flowers than No. 3,
(5) the heads completely mature and partly dried on the plant.

These five stages of flower development were dried under the following conditions:—

(*a*) In the shade.
(*b*) In the sun.
(*c*) With hot air at 60° C.

The experimental treatment of the flowers included the processing of—

(i) Untreated flowers.
(ii) Flowers treated with 0.5 per cent by volume of sulphur dioxide (SO_2) for 96 hours.
(iii) Treatment with 1 per cent by volume SO_2 for 48 hours.
(iv) Treatment with 2 per cent by volume of SO_2 for 20 hours.

He obtained the best results by treatment with 1 per cent of gas, and maximum stabilization was obtained at all stages of flower development and with varying methods of drying. At this percentage of gas whilst different stages of development naturally gave varying percentages of pyrethrins in the flowers, there was no great difference between the percentages obtained by varying the method of drying, nor was there any appreciable loss of pyrethrins in the dried flowers after a period of 60 days. Typical results obtained on the more mature flowers (stage No. 4 above) showed 1.40 per cent of pyrethrins in the treated dried flowers, as compared with 1.14 to 1.25 per cent of pyrethrins in the untreated dried flowers, variation in the latter depending on the method of drying. In other words, Covello obtained 12 to 24 per cent (mean 18 per cent) increased pyrethrins in the treated flowers. Further, the treated flowers were stable, whereas the untreated flowers in 60 days lost 8 to 10 per cent (mean 9 per cent) of pyrethrins on storage.

Owing to its distance from the pyrethrum growing areas, Dar es Salaam is not well situated for experiments with fresh flowering material. However, by arrangement with the Tanganyika Pyrethrum Board freshly cut flower heads were flown from Iringa and received in the laboratory late the same afternoon and processed at once. The first experiments were carried out in 4-gallon petrol tins fitted with removable wire trays and having a lid fitting into a lubricating oil seal which rendered the whole air-tight. The sulphur dioxide was generated from sodium sulphite, assayed by titration involving iodine and sodium thiosulphate. The corrected calculated theoretical rate of sulphite required to produce 0.5 and 1 per cent by volume of the container was treated with a small amount of dilute sulphuric acid in a porcelain dish at the bottom of the container. After treatment for 48 hours the treated and untreated flowers were dried but the resulting assays showed no appreciable difference between the one untreated and the two treated samples (1.30, 1.31 and 1.29 per cent of pyrethrins).

The experiment was therefore repeated and, on the second occasion, the cut flowers rather than flower heads were flown to Dar es Salaam. In addition, the treatment with sulphur dioxide was followed at varying times by tests for oxidases in small parallel experiments. Using 0.5 per cent by volume of sulphur dioxide and the starch iodide test for oxidases, at the end of 78 hours a strong positive reaction was obtained, and after this time up to 96 hours a faint positive reaction. After 100 hours' treatment a negative reaction was obtained, and the flowers were removed from the treatment chambers and dried with one of the negative controls. Using 1 per cent of sulphur dioxide, the negative oxidase reaction was obtained first at 70 hours and consequently the two lots of flowers under treatment with this percentage were removed from the treatment chambers and dried with their negative control.

The treatment chambers in the second experiment consisted of the 4-gallon tins used in the first experiment, and also glass desiccators. The results obtained are set forth in the following table:—

Nature of Experiment	% SO_2	Vol. of the containers in c.c.	Weight of No. 2 SO_2 in gms.	Weight of fresh flowers in gms.	Duration of shade drying	Duration of SO_2 treatment	Duration of drying in hrs. 40-45°C.	Weight of dried flowers in gms.	% Py. I Factor 44	% Py. II.	% Total Pyrethrins
					hrs.	*hrs.*	*hrs.*				
Untreated Flowers	—	—	—	95	100	—	47	20	0·65	0·55	1·15
	—	—	—	95	70	—	48	20·5	0·63	0·56	1·19
Glass desiccator containing SO_2	0·5	5,440	0·223	150	—	100	47	31·5	0·73	0·68	1·41
	1·0	4,000	0·328	150	—	70	48	32	0·65	0·63	1·28
Tin containing SO_2	0·5	18,184	0·745	200	—	100	47	38·5	0·70	0·66	1·36
	1·0	18,184	1·49	200	—	70	48	44	0·65	0·60	1·25

It will be noted that the flowers treated with 0.5 per cent by volume of sulphur dioxide for 100 hours gave the best result and showed an increased pyrethrin content varying from 18 to 22 per cent (mean 20 per cent), thus confirming Covello's work.

The results obtained are regarded as preliminary only, and it has been arranged that Mr. Beckley of the Scott Agricultural Laboratories, Kenya, will carry out further work on this subject, since he is in a much better position to obtain supplies of flowers.

If Covello's work is confirmed it would mean that treatment with a suitable percentage of sulphur dioxide would—

(1) give a product containing 15 or 20 per cent pyrethrins more than is given by the present methods of processing;

(2) the pyrethrin content of the product would be largely independent of variations in methods of drying;

(3) the product would be more stable than the present dried flowers, and this stability might well be maintained irrespective largely of the method of baling.

Whilst obviously the first step is further confirmation in the laboratory, there might well be some difficulties in translating the laboratory findings into commercial practice. If we assume that a reasonably air-tight room could be erected with internal measurements 20 x 10 x 10 ft. an automatic apparatus producing a mixture of sulphur dioxide and air might then displace the original air from the building if led in slowly at the bottom of the building with an exit point at the top opposite side of the building. 0.5 per cent by volume amounts to only 10 cubic feet of sulphur dioxide, and if we assume that double this quantity is required to displace the air from the building, 20 cubic feet would be required for a building of this size. The cost of 20 cubic feet, say 3½ lb., of sulphur dioxide, is difficult to estimate. In March, 1947, the ex-works price of sulphur dioxide in cylinders at New York was 43 East African cents per lb., but the landed cost Dar es Salaam of supplies for the refrigerating trade is at present in the region of Sh. 4 to 5 per lb. Taking the latter figure which covers the freight on cylinders, the total cost of treating a room of the size described would be some Sh. 15 to 20. When it is considered that loosely baled Tanganyika pyrethrum loses some 20 per cent of pyrethrins during transit to the consumer, if the sulphur dioxide stabilization process could be adopted commercially it would give a product containing some 40 to 50 per cent more pyrethrins at the buyer's factory than the present product (assuming pyrethrin content of present production 100 per cent, when it reaches the buyer it may be taken as 80 per cent, whereas the stabilization process yields flowers from the drier containing on the same scale roughly 120 per cent which does not show appreciable deterioration). The cost of treatment of the process is negligible compared with the results achieved.

We wish to thank the Director of Medical Services for permission to publish this note.

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NOTES ON SOME BROWSE PLANTS

By H. J. van Rensburg, M.Sc. (Rand), Pasture Research Officer, Department of Veterinary Science and Animal Husbandry, Mpwapwa, Tanganyika Territory

(*Received for publication on 15th September, 1947*)

The cultivation of leguminous fodder plants has very limited application in most parts of the Territory under present-day conditions. Clovers thrive only on the fertile Highland volcanic soils, for example in the Mbulu and Tukuyu districts of Tanganyika,—where they are indigenous. For the greater part lucerne can only be established under irrigation on intensively farmed land, while annual crops such as cow peas, velvet beans, groundnuts and sunn-hemp are grown for animal fodder only on a very limited scale. There is much scope for improvement and for extending the uses of these plants in areas where they can be grown successfully. Many introduced legumes have not proved very successful under our conditions of soil, climate and management, and although such species generally receive much publicity at the time of their introduction, their popularity soon wanes and they are forgotten until another wave of enthusiasm is generated and the whole process repeated once more.

One aspect, however, which is often overlooked is the utilization of indigenous leguminous species and other browse plants, particularly in the semi-arid region. *Acacia albida, A. benthamii, A. spirocarpa* and other species bear heavy yields of pods which are relished by live stock during the dry season when the annual grasses have withered and disappeared. People ask: "What do these animals eat that keeps them in such good condition?" At the same time remarking: "There seems to be nothing left but sand and dust". The following questions come to one's mind: Are these the "clovers" of the semi-arid regions forming a natural reserve of dry-season food? How can they be put to the best possible use while being protected and encouraged? Many of these plants are being destroyed daily by the axe, fire and the hoe, apparently without the matter being given a thought.

French [1], Henrici [3] and other workers found that these browse plants supply much-needed protein and minerals to live stock during dry periods, when the feeding value of the grasses has reached its lowest ebb and when many species are reduced to useless fibre. This source of protein and minerals should be fully developed and more carefully used. Some of these pod-bearing and other trees when present in adequate numbers would also provide shade in addition to a valuable food supply. Leaves and twigs of these trees, as well as of a large number of shrubs and creepers, are eagerly eaten by all types of live stock, particularly goats, and some species such as *Glycine javanica* form very useful constituents of mixed pastures.

A large number of other species also come into this group of leguminous browse plants. The branches of most Acacias are generally armed with thorns, some of which have recurved hooks or long spines. In spite of these most Acacia leaves are eagerly eaten and during the dry season when the pods fall (or when knocked off by the herdsmen) the stock concentrate in large numbers around the trees in order to pick up this valuable high-protein food.

If controlled grazing were applied, these edible plants would not become troublesome in grassland. Without adequate control, however, the danger exists that certain woody plants, including various undesirable species, some of which are not eaten by live stock, would form thickets which would oust the grasses as well as some of the smaller dicotyledonous edible species.

The following list includes some of the more important indigenous leguminous trees, shrubs and trailing plants which commonly occur in the semi-arid regions, the local names are given in brackets:—

Acacia albida (Mgunga).
A. benthamii (Mgunga).
A. pennata (Kikucha cha paka).
A. spirocarpa (Mgunga) and other species.
Albizzia harveyi.
Alysicarpus glumaceus (Mpakapaka).
Clitoria ternatea (Mfutafuta).
Crotalaria saxatilis.
C. senegalensis (Mkomanguku).
C. quartiniana and other species.
Dalbergia melanoxylon (Mpingo).
Desmodium caffrum.
Dolichos lablab (Mfiwi).
Glycine javanica.
Indigofera arrecta.
I. endecaphylla.
I. retroflexa.

I. suaveolens and other species.
Ormocarpum kirkii (Kitaji).
Tamarindus indica (Mkwaju).
Tephrosia incana.
T. purpurea (Mbaazi) and other species.
Vigna nilotica (Kunde mwitu).
V. vexillata.

There is also a large number of non-leguminous plants commonly browsed by stock. Some of the more common species are given in the following list:—

Acalypha fruticosa (Mchacha).
A. ornata and other species.
Achyranthes aspera (Turura).
Adansonia digitata (Boabab) (Mbuyu).
Boscia fischeri and other species.
Cadaba adenotricha and other species.
Capparis tomentosa (Mkoyo) and other species.
Combretum binderianum (Mganda wa simba).
C. purpureiflorum and other species.
Commiphora lindensis (Mchongoma) and other species.
Disperma parviflorum.
D. trachyphyllum.
D. quadrisepalum.
Fagara chalybæa (Mtata).
Grewia bicolor (Mkone).
G. platyclada.
G. similis.
Hibiscus micranthus (Mfagio).
Justicia betonica.
J. elliotii and other species.
Lannea stuhlmannii (Mnyumbu).
Markhamia obtusifolia (Mtalawanda).
Rhus incana.
Sida grewioides (Mtakawa dume).
Trema guineensis (Mpesi).
Tribulus terrestris (Dubbeltjie).
Waltheria americana.

Some plants are eaten only to a very limited extent during the dry season, while during the rest of the year they remain practically untouched, for example:—
Solanum panduræformæ (Mtunguruja) and
Wedelia menotriche (Mpepe).

Other species, such as the following, are not eaten by stock during any time of the year:—
Cassia singueana.
Courbonia edulus.
Elæodendron stuhlmannii.
Hippocratea obtusifolia.
Lasiosiphon eminii.
Sapium bussei and
Thylachium africanum.

The following list includes some leguminous fodder plants that have been introduced. On the whole, the perennial species have proved to be disappointing, and apart from some of the well known fodder plants such as lucerne, cow peas, velvet beans, soya beans and groundnuts there have not been any outstanding successes. Most of them have been failures either because they did not suit the conditions under which they were planted or because they did not get adequate attention. These plants include:—

Cajanus cajan (Pigeon pea).
Crotalaria juncea (Sunn hemp).
Glycine hispida (Soya bean).
Leucæna glauca.
Medicago sativa (Lucerne).
Mucuna pruriens (Velvet bean).
Samanea saman (rain tree).
Prosopis chilensis (Mezquit).
Pueraria hirsuta (Kudzu vine).
Stylosanthes mucronata.
Vigna unguiculata (Cow pea).
Trifolium usambarensis.

Lucerne has given very satisfactory results, but as has already been pointed out, yields best when grown under irrigation on fertile calcium-rich soils under highly developed and well-organized farming systems.

Cow peas, velvet beans, soya beans and groundnuts are all valuable annual crops which thrive under a wide range of climatic conditions. They have been grown successfully for many years, though they are not primarily cultivated for live stock in native areas, but are almost solely used for human consumption.

Pueraria hirsuta, syn. *P. thunbergiana* (Kudzu vine) has attained much popularity in parts of the United States of America, where it is used for anti-erosion work. It is reported to grow very vigorously on experimental stations in the Sudan, where it was found to overgrow and smother Elephant grass within a few years after planting. On the whole, results from Kudzu vine plots in South Africa and Tanganyika have not been very promising, and although it grows fairly well when regularly tended, it is doubtful whether it would be an economic success under rather adverse conditions. In Tanganyika termites rapidly destroy the vines shortly after the rainy season ends.

Some of the fodder trees were very promising in certain parts, but judging from results obtained at Mpwapwa with *Leucæna glauca, Prosopis chilensis* and other species they do not seem to be particularly fast-growing or heavy-yielding plants. On the whole, they do not seem

to have any advantage over many of the indigenous species which grow well and would develop quickly and grow with comparatively little trouble if encouraged. Furthermore, the latter can tolerate the local conditions better than exotic species.

Some of the smaller fodder plants such as *Trifolium, Stylosanthes* and *Desmodium*, which have been planted in semi-arid regions, often grow vigorously during the first season of establishment, only to disappear during the succeeding years when they are soon ousted by tall grasses and other plants unless very carefully tended and continuously cultivated. One of the great drawbacks is also the long and very severe dry season generally lasting for over six months.

The crux of the matter seems to be careful management and wise usage of indigenous plants, especially some of the leguminous species. These have long since adapted themselves to the adverse climatic conditions and on the whole they give good results.

Every effort should be made to prevent the useful species from being destroyed and in areas where their destruction has already taken place an attempt should be made to re-establish them.

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WEATHER FORECASTS BY RADAR

The use of radar as an aid to weather forecasting depends on the fact that a radar set can pick up echoes from water drops as well as from the more usual targets, such as ships or aircraft. When a radar beam encounters a water drop, some of the electric energy is scattered in all directions, and a tiny fraction is returned back towards the radar receiver. Provided the drops are sufficiently numerous, and, what is more important, sufficiently large, an easily identifiable echo is observed. The importance of drop size is easily appreciated when one remembers that the scattering power of a drop for a given wave-length is proportional to the sixth power of its radius. It has been found, for example, that even the drops in light rain can return a recognizable echo, but the smaller drops in drizzle or in fine weather cumulus cloud cannot be detected with the equipment in use at present.

It is common knowledge that the largest drops are found in the interior of thunderstorm clouds, and showers are the easiest of all weather phenomena to detect by radar.

The range of detection is the same as for orthodox targets, that is to say, between 100 and 200 miles for thunderstorms.

The most convenient type of radar presentation for weather-forecasting use is the Plan Position Indicator, which gives the operator something comparable to a bird's eye view of all the radar echoes within a radius of, say, 100 miles, although this radius can be adjusted to be more or less according to convenience. A glance at the plan indicates the whereabouts of showers or areas of general rain, and by watching the screen for a few minutes an accurate estimate of the speed of motion of the front edge of the rain belt can be made. By this means the forecaster can predict the onset of rain to an accuracy of a few minutes. The forecasting of heavy showers or thunderstorms is more difficult because they appear to develop very suddenly in a non-continuous manner, but it is possible to give at least 15 minutes' warning and even this may be of great value. The downpour associated with a thunderstorm is frequently sufficient to put electric power systems out of action for some time, but, given 15 minutes' warning, it may be possible to arrange for alternative supplies and thus avoid serious dislocation of essential services.

Because of the sensitivity of radar to drop size, there seems a possibility that it may be used to explore the interior of clouds in much the same way that X-rays are used to explore the interior of metals. Research on this subject, which cannot fail to improve our understanding of the physical causes of cloud and rain formation, may have far-reaching effects on the improvement of weather forecasting generally.

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BLUE GUM COPPICE FOR WOODFUEL

By S. H. Wimbush, Assistant Conservator of Forests, Kenya

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Blue Gum (*Eucalyptus globulus*) is planted extensively in Kenya for woodfuel for railway locomotives, drying kilns for pyrethrum flowers and for industrial and domestic purposes. It is chosen on account of its rapid growth, satisfactory burning qualities, and strong power of coppicing from the stumps of felled trees which makes the regeneration of the second crop both cheap and rapid. Within a month or so after felling, coppice shoots sprout from the sides of the cut stumps and grow rapidly, reaching 15–20 feet by the end of the second year. At this stage every stump carries a dense growth of shoots of which some are larger and more robust than others. It is the practice of the Forest Department to select three of the best stems for retention, evenly spaced round the perimeter of the stump, and to cut or break off the remainder. These three stems may then be left to grow to merchantable size or they may later be reduced in number to give the remainder more room. Foresters differ in opinion as to whether the greatest yield of wood is obtained by retaining all three stems or by a further thinning to two stems or even to a single stem per stump. In 1935 a set of experimental plots was laid out at Uplands (altitude 7,800 ft.) to investigate this point. A 16-year old plantation (spaced nine feet by nine feet) had just been felled, and six plots representing three treatments of coppice were made, each plot being half an acre.

The coppice in all plots was thinned to three stems per stump at eighteen months old. Six months later coppice shoots in two of the plots were further reduced to two stems per stump, and in the remaining two plots to one stem per stump. At nine years old, when the plots were nearly due for felling for railway woodfuel, the stems in the plots were measured and the statistics obtained are shown in the appended table.

Results

From a study of these results the following observations are made:—

Number of Stems per Stump.—There is not room for three coppice stems to grow for nine years from a single stump at a spacing of nine feet between stumps. One stem generally becomes suppressed (*see* columns 3 to 5).

Volume of wood per tree.—The volume of wood per tree produced by the coppice is approximately the same whether it has carried three stems, two stems, or one stem (*see* columns 7 and 8).

Basal area per tree is greater in the 3-stem and 2-stem plots than in the 1-stem plots but this is counteracted by their shorter average height and greater taper.

Yield of wood per acre.—The yield of wood per acre is not affected by the number of stems allowed to grow from each stump (*see* columns 11 and 12). The difference in the yield of wood from the six plots under observation are shown to be insignificant when assessed by the statistical method given in the Indian Silvicultural Manual, Vol. I.

Diameter.—The diameter at breast height is directly influenced by the number of coppice stems carried on the stump. The average d.b.h. at nine years old in this particular case was 5.8 in. in the 3-stem plots, 6.2 in. in the 2-stem plots, and 7.5 in. in the 1-stem plots.

Labour.—Woodfuel billets supplied to the Kenya and Uganda Railways must not be larger than to pass through an 8-inch diameter ring. Billets that will not do so must be split, and the significance of diameter can thus be seen. In the present experiment the butt sections of the following number of stems would have to be split to pass through an 8-inch ring:—in the 3-stem plots, 4 per cent; in the 2-stem plots, 7 per cent; in the 1-stem plots, 22 per cent of the total number of stems.

This disadvantage of the 1-stem coppice is offset by the far greater length in running feet of stem to be cut to billet-lengths in the 2-stem and 3-stem plots than in the 1-stem plots.

In Kenya, however, these two points will not generally affect the cost of felling and stacking the fuel, as this is done universally on piecework based on the stacked volume of the woodbillets.

Coppice Treatment	Plot No.	Plot Statistics: Number of Stems	Plot Statistics: Number of Trees	Average Number of stems per tree	Basal Area per tree	Solid Vol. per tree U/B	Stacked Vol. per tree	Mean DBH	Mean Height	Form Factor	Per Acre: Solid Vol. U/B	Per Acre: Stacked Vol. U/B	Per Acre: Basal Area	Mean Annual Increment (9 years): Vol.	Mean Annual Increment (9 years): B.A.	Conversion Factor Solid to Stacked Vol.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
					sq. ft.	*cub. ft.*	*st. c. ft.*	*in.*	*ft.*		*cub. ft.*	*st. c. ft.*	*sq. ft.*	*cub. ft.*	*sq. ft.*	
Thinned to 3 stems per stump ..	E.23	300	141	2·1	0·37	8·3	16	5·6	73	·312	2,362	4,488	103·6	262	11·5	1·9
ditto	E.25	298	144	2·1	0·40	9·5	14½	6·0	76	·313	2,676	4,216	115·7	299	12·8	1·6
Mean of E.23 and E.25 ..		299	142	2·1	0·38	8·8	15	5·8	74	·312	2,519	4,352	109·6	280	12·1	1·7
Thinned to 2 stems per stump ..	E.24	185	104	1·8	0·40	10·9	17	6·5	81	·330	2,268	3,608	84·4	252	9·4	1·6
ditto	E.26	287	166	1·8	0·33	8·5	12	6·0	79	·322	2,850	4,080	112·0	317	12·4	1·4
Mean of E.24 and E.26 ..		236	135	1·8	0·36	9·5	14	6·2	80	·326	2,559	3,844	98·2	284	10·9	1·5
Thinned to 1 stem per stump ..	E.22	131	131	1	0·30	8·7	14½	7·4	82	·359	2,296	3,808	77·8	255	8·6	1·7
ditto	E.27	135	135	1	0·31	9·5	14	7·6	83	·363	2,584	3,808	85·8	288	9·5	1·5
Mean of E.22 and E.27 ..		133	133	1	0·31	9·2	14	7·5	82	·361	2,440	3,808	81·8	271	9·0	1·6

Conversion Factor.—Conversion factor from solid to stacked volume of wood is approximately the same (1.6) for 1-stem and 2-stem coppice.

Form.—The 1-stem coppice trees are in general straighter than the 3-stem and 2-stem trees. For building-poles, therefore, the 1-stem treatment is the most suitable. For woodfuel straightness is of no account, but the long thin tops found in 3-stem trees increase the proportion of thin billets which are not generally favoured for woodfuel for locomotives and industrial purposes. Straightness of stem is of importance if the plantation owner should decide to keep the plantation to grow on to timber size rather than to utilize it for fuel at an early stage.

Conclusions

(1) On a rotation of nine to ten years the same yield of wood may be expected from 1-stem coppice as from 2-stem or 3-stem coppice.

(2) Straighter stems are likely to be obtained from 1-stem coppice. Trees carrying three stems per stump are particularly liable to be crooked.

(3) A good average size of billet suitable for woodfuel is obtained in nine to ten years from 2-stem coppice. The butts of the larger trees in 1-stem coppice are on the large size for locomotive fuel and need to be split. Coppice grown with more than two stems per stump yields a high proportion of thin billets which require more handling and burn quicker than normal sized billets.

It is therefore recommended that blue gum coppice should be grown with two stems to every original stump for woodfuel. If, however, the owner is in doubt whether the trees will be required for woodfuel it is recommended that coppice be thinned to one stem per stump after growing two to three years at two stems per stump. The trees can then be grown for fuel, poles or timber as may eventually be required.

Time of Thinning

The first thinning of the multiple coppice shoots which grow from the stumps of felled blue gum trees should be done when the coppice reaches about 20 feet in height. The three best shoots on each stump should be left and the remainder cut or pulled off the stump. A year later the weakest of the three stems should be removed, leaving two good stems to each stump. If, however, it is desired to keep only one stem growing from each stump, for the reason given in the previous paragraph, the second operation should remove two stems leaving a single strong stem on every stump.

WEED KILLERS

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Weed killers have been in use for many years, originally to keep paths free from plant growth. The first of these weed killers was an arsenical preparation, but more recently sodium chlorate has been employed. Both are total herbicides, and their effects are very rapid, causing almost immediate scorching of the leaves, followed by death of the roots. The effects, too, persist for a considerable time.

Such weed killers are, of course, completely unsuited for use in crops. Some thirty years ago, it was noted that top dressings of ammonium sulphate to cereal crops were often accompanied by the scorching of the leafage of weeds, due to the removal of water by the ammonium sulphate crystals on the leaves. More efficacious materials have since been employed, notably ferrous sulphate, copper sulphate, copper chloride, dilute sulphuric acid and, more recently still, dinitro-orthocresol or D.N.O.C. The application of the first four of these involves the use of special spraying equipment, most of which is beyond the resources of the general farmer, and in Britain such spraying was usually undertaken by firms specializing in the subject. Incidentally, sprayers for dilute sulphuric acid had to be lead-lined; to-day, to overcome this difficulty, a fine mist spray of concentrated sulphuric acid is employed which does not require the use of lead-lined plant.

All this last group of differential weed killers produce very rapid effects upon weeds. Within a few hours they are scorched, and they die in the course of a day or two. In fact, the effect is most spectacular. There are, however, some after-effects upon the soil which may be deleterious.

Recently, work has been conducted upon the new synthetic plant hormones, which have been employed in very dilute solutions for the encouragement of the rooting of cuttings; if used at greater concentrations, they kill the cuttings. Some have been employed to prevent premature fruit drop, and here, too, the concentration must be very low or the trees suffer. It was observed that when a comparatively strong solution of one of these plant hormones was sprayed over a mixture of grass and dicotyledonous weeds, the weeds were eventually killed and disappeared while the grass was stimulated. The early synthetic hormones are expensive to produce, so intensive research was instituted which resulted in the production of several easily prepared associated materials which do kill most non-gramineous plants when employed at suitable concentrations. The two generally used to-day are 2-methyl 4-chlorophenoxy acetic acid, commonly known as M.C.P.A., and 2-4 dichlorophenoxy acetic acid commonly known as D.C.P.A., or, in America, as 2 4 D. A third compound is also used in America, trichlorophenoxy acetic acid, which has been called T.C.P.—a pity in view of the well-known proprietary pharmaceutical preparation.

The effects of these weed killers is nothing like as spectacular as those of the second class mentioned above (ammonium sulphate, etc.). At first, there is a drooping of the leaves, very similar to ordinary wilting. A day or two later, the plants begin to twist, and even if they do not die for many days death is certain. In addition, there is a well marked stimulation of the grass crop. In my first experiments, I was frankly highly disappointed and gave up inspection of my experimental plots. I visited them a month after treatment and was most surprised to find that practically all the weeds had been killed in the treated plots and that the grass growth was visibly better than on the controls. Further experiments have confirmed my opinion that these hormone weed killers are very valuable for the control of weeds in cereal and grass crops.

In the course of these experiments, it has been established that a lot of the weeds are very sensitive to M.C.P.A. dusts and sprays, and others are more resistant, while some few appear to be hardly affected at all. Dusts are less effective than sprays.

Results so far obtained are summarized in the table below:—

Sensitive (Destroyed by 1 lb. active agent per acre):—

- *Amaranthus* spp., Pigweed.
- *Brassica* sp., Charlock.
- *Commelina* spp., Listening Willie (Spiderwort).
- *Chenopodium botrys*, Stinkweed (Goosefoot).
- *Datura stramonium* (seedling), Datura.

Erigeron.

Tribulus terrestris, Double thorn (Caltrops).

Vigna vexillata, Wild Cowpea.

Slightly Resistant. (Destroyed by 2–3 lb. active agent per acre.):—

Alternanthera repens, Joy weed.

Bidens pilosa, Blackjack.

Datura stramonium (flowering), Datura.

Galinsoga parviflora (seedling) Macdonaldii.

Lactuca taraxacifolia, Wild lettuce.

Tagetes minuta (young), Mexican marigold.

Trifolium spp., Clover.

Veronica sp.

Resistant (Killed or affected by 4 lb. or more active agent per acre):—

Galinsoga parviflora, Macdonaldii.

Oxalis spp., Wood sorrel.

Oxygonum atriplicifolium, Devil thorn.

Cyperus spp., Nut grass.

Both M.C.P.A. and 2-4 D will shortly be available in East Africa, the former from Plant Protection, Limited, under the name of "Agroxone", and the latter from Messrs. May and Baker's Agents under the name of "Weedone".

WATER DEMANDS BY MAIZE AND SORGHUM

In East Africa water is often a limiting factor in obtaining high yields of maize and sorghums. The crops may be on good, well-manured soils, but, if they do not get rain at the right time, or if the soil does not hold sufficient water to maintain normal growth throughout the drought period, yields may be low.

There is generally one period in the life of the plant when its demand for water reaches a peak. In cereals this critical period is known to be from the start of maximum elongation of the stem to flowering, which generally takes several weeks. The accompanying diagram, which is derived from records of average daily transpiration of maize and sorghum at Amani, illustrates this.

Except for differences due to species, the curves are similar, showing low water requirements while the plants are young, rising to a broad peak during heading and flowering, thereafter diminishing as the seed matures and the plants die. The secondary rise shown for sorghum was due to the transpiration of developing tillers and branches in the variety used in the experiment.

It is obvious that this important period of peak demand must be anticipated either by conservation of soil moisture, by planting so that the peak falls in or immediately after the most suitable period of the average rains, by irrigation, or by a combination of some or all these methods. A very large amount of water is transpired daily by an acre of plants during the peak period. For example, the sorghum plants at peak transpired less than maize, yet between the eleventh and sixteenth weeks from planting they each transpired an average of just over ¾ lb. of water per day. If they were spaced as in South Africa, some 6 inches between plants in rows 3½ feet apart, or approximately 26,800 plants per acre, then the crop would remove 9 tons or 0.09 inches of water daily from that acre. In the U.S.A. it has been stated that in the 5 week period from heading to flowering sorghum requires a minimum of 0.1 inch of water a day for normal growth and 0.15 inches for high yields. This is a heavy demand for soil moisture, for other losses by evaporation and the transpiration of weeds are going on simultaneously. In dry areas, therefore, every possible means should be used to provide water in sufficient quantity throughout the critical period of peak demand.

It should be noted that the above figures are only a rough guide to plant needs. They do not enable us to estimate how much rain or irrigation is required in a particular area, for these depend on spacing, climate, soil and weed growth among other factors.

E.A.A.R.I., Amani, J. GLOVER
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GRAZING EVALUATION BASED ON A SCANDINAVIAN SYSTEM

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Dairy farming in East Africa has reached a point of development when on many farms a more correct knowledge of the feeding value of the pastures is required. Without such knowledge, based on real records, proper use of land is very difficult. Most of our cattle are entirely dependent on grazing and it is not good enough to say, "this land is able to keep one cow to one acre" or "one cow to ten acres". A cow is not a good standard of measurement, but the use of starch equivalent values in this respect is better and much more accurate.

In English handbooks we find figures and tables for the purpose of computing feed rations, but few figures are given which can be used for grazing evaluation. This means the opposite of computing a balanced ration. Here the ration is entirely obtained by grazing, however unbalanced it may be, and we want to know its energy value expressed in starch equivalent. In Scandinavia, however, we find standards for this purpose, worked out by the late Professor L. Fredriksen, which were adopted by the Nordic Agricultural Scientists' Association at their congress in Copenhagen in 1935, and which are used in Denmark, Sweden, Norway, Finland and Iceland. The methods used in these countries are well worth studying, as they have raised the output of dairy products by more than 25 per cent during the last 50 years and at the same time have lowered the feed consumption. The statistical material available to the Scandinavian scientists is immense. Over one million cows were under continuous observation during the years between the two world wars. Complete records have been kept of the food consumed and the quantity and fat percentage of milk produced. This work is performed by the cow-testing associations, which were first started in 1895.

The above-mentioned standards (Norms) are given below and at the end the reader will find an example where the evaluation system is applied.

Certain difficulties have arisen while transferring these Norms, as the Scandinavians use the metric system and the Scandinavian feed-unit which is based on milk output, with older traditions than the Kellner starch values, based on fattening of oxen, as used by the British farmer. A slight difference between the figures and those corresponding in the bulletin published by the Ministry of Agriculture and Fisheries "Rations for Live Stock" will be found, and therefore the reader will perhaps excuse an explanation of how the basic figures have been arrived at when translating feed unit into starch equivalent (s.e.). I have taken the following as a basis: 2.5 kg. milk with 4 per cent fat content and 750 calories milk energy per kilogram is produced by 1 feed-unit. According to the figures given by the Pennsylvania Institute of Animal Nutrition, 693 cal. milk energy will be produced by 1,000 cal. metabolized energy, and thus 1,875 cal. milk energy (1 f.u.) equals 2,705.6 cal. metabolized energy. With 1 kg. starch gross energy 4,230 cal., and according to Kellner, a loss of 10.1 per cent as methane, etc., we get 3,802.77 metabolized energy to 1 kg. s.e. and 0.71 kg. or 1.57 lb. s.e. = 1 feed unit.

Calculation of grass consumed in starch value is founded on the animal's estimated need of starch equivalent for maintenance and the s.e. estimated for production.

Maintenance starch equivalent is read from Table I on the basis of weight or breast circumference. Figures supplied for the latter apply to average heavy breeds only (like Ayrshires).

Production starch equivalent for growth is calculated with the help of Tables II–V. For young animals Table II is to be used. The need of production s.e. per lb. of growth is shown for animals of different states of condition or fatness. It is presumed that the need of food per lb. growth varies from 0.8 s.e. by 1–2 months old ill-conditioned animals to 3.6 s.e. by nearly full-grown fat animals. The use of Table II is dependent on knowledge of age, growth and state of condition of the animals.

If, for instance, the age of an animal is 12 months, the condition normal and the daily growth 1.3 lb., its need of food is caculated to $1.3 \times 1.8 = 2.14$ production s.e. daily. Another example would be an animal 18 months old which is coming on grass in a half-thin state and is returned to stable 22 months old as half-fat. The growth during the period has been 0.9 lb. daily. The food consumption should be calculated to $0.9 \times 1.9 = 1.71$ production s.e. at the beginning and $0.9 \times 2.8 =$

2.52 p.s.e. at the end, or a daily average of 2.1 p.s.e.

The production s.e. thus calculated is added to the maintenance s.e. in Table I, and the daily food consumption is found.

A correction in the calculation of growth could be done for heifers in calf whose weights are strongly affected by the foetus development during the last months of the gestation period. If the weighing is done at the start of grazing or at the beginning of the last three months of the gestation period, while the final weighing is done after calving, some pounds ought to be added to the found increase in growth before the amount of production s.e. is calculated. If, however, the weighing at the beginning of the period is done before the sixth month of pregnancy, while the weighing at the end of the period is done during the sixth to ninth month of the gestation, a few pounds ought to be deducted from the found increase in growth before the amount of production s.e. is calculated. In Table III is found how many pounds in such a case ought to be added or deducted.

To give an example. A heifer is put on grazing in the eighth month of her pregnancy and she will weigh, on account of the foetus, 75–113 lb. more than normal; if she is taken off the grazing after calving down the found growth increase ought to be corrected by adding this amount. As another example could be taken a heifer which is put on grazing in the sixth month of pregnancy; its weight would then be 25–39 lb. above normal. If she is taken away to stable just before calving, her weight would be 100–150 lb. above normal, and from the growth found during the period has to be deducted 75–111 lb.

If such a correction of growth is done, an addition for foetus development ought to be made according to the rules for milking cows (*see* Table VII).

In case the amount of growth cannot be judged with accuracy, Table IV will make it possible to read off the total s.e. daily, taking the animal's age and expected mature weight as a starting point, a normal and even development being assumed. In columns 2 and 3 of the table is shown how much animals of different ages could be expected to weigh in percentage of mature weight. In the following six columns is shown the total s.e. for animals with the expected mature weight of 700–1700 lb. The remarks at the bottom of the columns should enable one to make small corrections according to the condition of the beast. For a thin animal with an expected mature weight of 1,100 lb., for example, one should read a total s.e. as for a normal animal with an expected mature weight of 900 lb. Finally, if both age and growth are unknown, one could get an approximate estimation of the daily food consumption by adding 1.5 to 2.5 production s.e. to the maintenance s.e. found in Table I, estimating from the animal's breast circumference.

For bulls, oxen, non-pregnant heifers, and cows more than 27 months old the production s.e. is estimated with the help of Table V. In this it is presumed that the food consumption per lb. growth varies from 2 p.s.e. in a thin beast to 3.6 in a fat animal, when one counts 2.8 s.e. for a beast in normal condition. The table is made so that the condition of the beast at the beginning and the end of the period can be taken into consideration. If, for instance, the condition is thin at the beginning and half-fat at the end, food consumption is taken 2.6 p.s.e. per lb. growth.

Starch equivalent for milk cows can be read in Table VI, starting from body weight or breast circumference, milk yield and fat content. If one has, for instance, a cow of 900 lb. weight and producing 26 lb. milk with 4.5 per cent fat content, one has to reckon with 13.4 s.e. daily. For milk amounts and fat percentages which are not in the table the nearest higher numbers should be read, and, when weight is not in the table, the nearest lower amount.

The need of food could be more accurately estimated by adding to the maintenance s.e. found according to weight or breast circumference in Table 1, 0.28 production s.e. per lb. 4 per cent measure milk (Measure milk = (lb. milk × 0.4) + (lb. butterfat × 15)). If, for instance, a production is found of 40.7 lb. milk with 3.7 per cent fat and a live weight of 1,150 lb., then the total s.e. is found to be

$$\left(40{\cdot}7 \times 0{\cdot}4 + \frac{40{\cdot}7 \times 3.7 \times 15}{100}\right) \times 0{\cdot}28 \text{ p.s.e.} + 6{\cdot}4 \text{ m.s.e.} = 17{\cdot}3$$

An addition for foetus growth is accounted for according to Table VII for cows in calf, estimating from the weight or breast circumference of the beast.

For a cow of 900 lb. in the seventh month of the gestation period this addition for foetus growth amounts to 0.75 p.s.e. daily, and for a cow of 1,200 lb. the same addition in the last

month of the gestation period is 2.55 p.s.e. daily.

For milking cows not in calf, whose condition during the grazing period has altered materially, an addition or reduction should be made for gain or loss according to Table V.

All additional food given to grazing cattle is booked by itself and taken away from the calculated amount s.e. in grass.

On many farms in East Africa this Scandinavian system for grazing evaluation certainly could be used as it stands, but as a rule the animals in Scandinavia expend all their energy in the field, where they graze day and night and where they also are milked, while out here the herd is usually driven some distance to and from a night boma and milking shed; also the cattle are dipped at regular intervals. All this additional energy expended should be taken into consideration, otherwise a comparison between different fields or different farms would be of little value. For practical reasons a table for such work-production must be simple, and its scientific accuracy must suffer by simplification. The energy used on a wet and soft road or a hard one is different and it differs with the temperature and altitude and how fast the animals are driven, etc. For practical purposes, however, I suggest that 5 per cent is added to the maintenance s.e. each time the cattle are dipped. The distance the animals have to walk from and to the field on a level road is estimated, and 3 per cent of maintenance s.e. per mile is counted as work production and 1 per cent extra for every 100 feet rise when the cattle have to pass up and down a hill.

As a simplified example how this grazing evaluation system can be used I have chosen a herd of cattle as described by J. F. Byng-Hall in an article "The Effect of Milk Yields and Pasture Values on the Cost of Butterfat Production", in this Journal, Vol. V, No. 2. The herd consists of 313 cows and six bulls, and each year 50 heifer calves are reared. The birthrate is 85 per cent per annum and each cow is assumed to milk for 274 days with an average daily yield per cow in milk of 14 lb. and butterfat 3.75 per cent. On this imaginary farm all the cows weigh 1,140 lb. and the bulls 1,824 lb. each; the calves' weight at birth is 68 lb. and they are brought to bull when two years old. The acreage available for grazing is 1,676 acres. The cows have to walk daily as an average one mile from and to the night enclosure and there is a rise of 50 feet on the way. Dipping is done every fifth day. Two hundred tons of maize ensilage is fed during the year in periods of drought.

313 cows, maintenance s.e. ..	2,003.20
6 bulls maintenance s.e. ..	52.80
2,800 lb. milk, 3.75 per cent butterfat production s.e. ..	765.38
Foetus growth	121.00
100 heifer calves receive from grazing. (During first nine months half the energy is received from whole and skim milk)	496.95
Weight increase = 20 per cent of finishing weight for 50 animals	87.45
Energy spent by cows and bulls on walking outside the actual grazing ground	71.96
Energy spent on dipping ..	23.80
Daily total s.e.	3,622.54
Yearly total s.e.	1,322,227.10
Less 200 tons ensilage ..	44,800.00
One year's total from grazing s.e.	1,277,427.10

This last figure divided by 1,676 or the acreage available for grazing shows the net lb. starch equivalent obtained during one year to be 762.19 per acre.

It is interesting to compare this figure with similar figures from northern Europe, although climatic conditions are widely different and grazing is confined to a few months of the year. In the middle of Sweden natural forest grazing is giving 300–500 s.e./acre and fair developed pastures 1,600–1,900 s.e./acre.

It has to be observed that the energy value arived at probably could have been higher if the grazing had been balanced by protein concentrates and carotene, the precursor of Vitamin A, especially during the dry periods of the year.

The energy spent on walking and dipping is valued to 95.76 s.e. or as much energy as is needed for the production of 38½ gallons of milk. To reduce unnecessary expenditure of energy is a point where the skilled farmer could make savings. A better result could perhaps be achieved by using a somewhat smaller breed (or less highly bred), which economizes more energy by walking and feeding.

REFERENCE

Beretning om Nordiske fordbruks forskeres Forenings Femte Kongres. Copenhagen, July, 1935.

TABLE I.

Maintenance S.E. for Cattle.

M.S.E.	Weight in Lb.	Breast Circumference	M.S.E.	Weight in Lb.	Breast Circumference
		ft. in. ft. in.			ft. in. ft. in.
·9	55–65	2 ¾–2 2¾	5·2	815–840	5 4¼–5 5
1·0	65–75	2 2¾–2 4¼	·3	840–870	5 5 –5 5½
·1	75–85	2 4¼–2 5¾	·4	870–890	5 5½–5 6¼
·2	85–100	2 5¾–2 7	·5	890–920	5 6¼–5 7
·3	100–115	2 7 –2 8	·6	920–945	5 7 –5 7½
·4	115–130	2 8 –2 9	·7	945–970	5 7½–5 8¼
·5	130–140	2 9 –2 10	·8	970–995	5 8¼–5 9
·6	140–155	2 10 –2 11	·9	995–1,020	5 9 –5 9½
·7	155–165	2 11 –3 0	6·0	1,020–1,045	5 9½–5 10¼
·8	165–180	3 0 –3 1	·1	1,045–1,070	5 10¼–5 11
·9	180–195	3 1 –3 2	·2	1,070–1,100	5 11 –5 11½
2·0	195–210	3 2 –3 3	·3	1,100–1,130	5 11½–6 ¼
·1	210–225	3 3 –3 4	·4	1,130–1,155	6 ¼–6 ¾
·2	225–240	3 4 –3 5	·5	1,155–1,180	6 ¾–6 1½
·3	240–250	3 5 –3 6	·6	1,180–1,205	6 1½–6 2
·4	250–265	3 6 –3 7	·7	1,205–1,230	6 2 –6 2¾
·5	265–280	3 7 –3 8	·8	1,230–1,255	6 2¾–6 3¼
·6	280–300	3 8 –3 9	·9	1,255–1,285	6 3¼–6 4
·7	300–320	3 9 –3 10	7·0	1,285–1,315	6 4 –6 4½
·8	320–335	3 10 –3 11	·1	1,315–1,340	6 4½–6 5
·9	335–355	3 11 –5 11¾	·2	1,340–1,370	6 5 –6 5½
3·0	355–370	3 11¾–4 ¾	·3	1,370–1,400	6 5½–6 6
·1	370–390	4 ¾–4 1½	·4	1,400–1,430	6 6 –6 6½
·2	390–410	4 1½–4 2½	·5	1,430–1,460	6 6½–6 7
·3	410–430	4 2½–4 3¼	·6	1,460–1,490	6 7 –6 7½
·4	430–445	4 3¾–4 4¼	·7	1,490–1,520	6 7½–6 8
·5	445–470	4 4 –4 5¾	·8	1,520–1,550	6 8 –6 8½
·6	470–490	4 5¾–4 5½	·9	1,550–1,580	6 8½–6 9
·7	490–515	4 5½–4 6¾	8·0	1,580–1,605	6 9 –6 9½
·8	515–530	4 6¾–4 7½	·1	1,605–1,630	6 9½–6 10
·9	530–555	4 7½–4 8¼	·2	1,630–1,660	6 10 –6 10½
4·0	555–580	4 8¼–4 9	·3	1,660–1,690	6 10½–6 11
·1	580–600	4 9 –4 9½	·4	1,690–1,720	6 11 –6 11½
·2	600–620	4 9½–4 10¼	·5	1,720–1,750	6 11½–7 0
·3	620–640	4 10¼–4 11	·6	1,750–1,780	7 0 –7 ½
·4	640–665	4 11 –4 11½	·7	1,780–1,810	7 ½–7 1
·5	665–685	4 11½–5 ¼	·8	1,810–1,845	7 1 –7 1½
·6	685–705	5 ¼–5 1	·9	1,845–1,880	7 1½–7 2
·7	705–725	5 1 –5 1½	9·0	1,880–1,910	7 2 –7 2½
·8	725–745	5 1½–5 2¼	·1	1,910–1,945	7 2½–7 3
·9	745–770	5 2¼–5 3	·2	1,945–1,975	7 3 –7 3¼
5·0	770–795	5 3 –5 3½	·3	1,975–2,005	7 3½–7 4
·1	795–815	5 3½–5 4¼	·4	2,005–2,040	7 4 –7 4½

TABLE II.

S.E to Young Growing Cattle.

Age in months	P.S.E. per lb. growth when the animal's condition is :— Thin	— to —	Normal	— to —	Fat
1	0·8	0·9	1·0	1·1	1·2
2	0·8	1·0	1·1	1·2	1·3
3	0·9	1·0	1·1	1·3	1·4
4	0·9	1·1	1·2	1·4	1·5
5	1·0	1·1	1·3	1·4	1·6
6	1·0	1·2	1·4	1·5	1·7
7	1·1	1·3	1·4	1·6	1·8
8	1·2	1·3	1·5	1·7	1·9
9	1·2	1·4	1·6	1·8	2·0
10	1·3	1·4	1·6	1·8	2·1
11	1·3	1·5	1·7	1·9	2·2
12	1·4	1·6	1·8	2·0	2·2
13	1·4	1·6	1·8	2·1	2·3
14	1·5	1·7	1·9	2·2	2·4
15	1·5	1·8	2·0	2·2	2·5
16	1·6	1·8	2·1	2·3	2·6
17	1·6	1·9	2·1	2·4	2·7
18	1·7	1·9	2·2	2·5	2·8
19	1·7	2·0	2·3	2·6	2·8
20	1·8	2·1	2·3	2·6	2·9
21	1·8	2·1	2·4	2·7	3·0
22	1·9	2·2	2·5	2·8	3·1
23	1·9	2·2	2·6	2·9	3·2
24	2·0	2·3	2·6	3·0	3·3
25	2·0	2·4	2·7	3·0	3·4
26	2·1	2·4	2·8	3·1	3·5
27	2·1	2·5	2·8	3·2	3·6

TABLE III.

Correction for Growth by Pregnant Heifers.

When the first weighing is done at the end of the	Correction of the growth for weight classes: Up to 800 lb.	800-1,000 lb.	1,000-1,200 lb.
6th month of gestation	+25	+32	+39
7th „ „	+50	+64	+76
8th „ „	+75	+95	+113
9th „ „	+100	+125	+150
When the last weighing is done at the end of the			
6th month of gestation	÷25	÷32	÷39
7th „ „	÷50	÷64	÷76
8th „ „	÷75	÷95	÷113
9th „ „	÷100	÷125	÷150

TABLE IV.

S.E. TO YOUNG GROWING CATTLE

	Approximate weight in per cent of final weight		Maintenance plus production s.e. per beast and day when the animal's disposition to final weight at normal growth is in lb.					
	From–to	"Normal"	700	900	1,100	1,300	1,500	1,700
	lb.	*lb.*						
1 2	7–13 10–18	10·0 14·3	1·9 2·2	2·4 2·7	2·8 3·2	3·2 3·7	3·7 4·2	4·1 4·6
3 4	14–22 18–26	18·4 22·3	2·5 2·7	3·0 3·3	3·6 3·9	4·1 4·5	4·7 5·1	5·2 5·7
5 6	22–30 26–34	26·2 30·0	3·0 3·2	3·6 3·9	4·2 4·5	4·8 5·2	5·5 5·8	6·1 6·4
7 8	30–38 33–41	33·6 37·1	3·4 3·6	4·1 4·3	4·8 5·0	5·5 5·8	6·2 6·5	6·8 7·2
9 10	37–45 40–48	40·5 43·8	3·8 3·9	4·5 4·7	5·3 5·5	6·1 6·3	6·7 7·1	7·5 7·9
11 12	43–51 45–55	46·9 50·0	4·0 4·2	4·9 5·0	5·7 5·9	6·4 6·7	7·3 7·5	8·1 8·3
13 14	48–58 51–61	52·9 55·8	4·3 4·4	5·2 5·3	6·0 6·2	6·9 7·1	7·7 7·9	8·5 8·7
15 16	54–64 56–66	58·5 61·3	4·5 4·6	5·4 5·6	6·4 6·5	7·2 7·4	8·0 8·2	9·0 9·2
17 18	59–69 62–72	63·9 66·4	4·7 4·8	5·7 5·8	6·7 6·8	7·6 7·8	8·5 8·6	9·3 9·5
12 20	64–74 67–77	68·9 71·2	4·9 5·0	5·9 6·1	7·0 7·1	7·9 8·0	8·8 8·9	9·7 9·8
21 22	69–79 71–81	73·5 75·8	5·1 5·2	6·2 6·2	7·2 7·3	8·1 8·2	9·0 9·1	9·9 10·0
23 24	73–83 75–85	77·9 80·0	5·2 5·3	6·3 6·4	7·4 7·4	8·3 8·3	9·2 9·2	10·1 10·2
25 26	76–88 78–90	81·8 83·4	(thin)	(fat) (thin)	(fat) (thin)	(fat) (thin)	(fat) (thin)	(fat)
27	79–91	85·0	900	700 1,100	900 1,300	1,100 1,500	1,300 1,700	1,500

TABLE V.

PRODUCTION S.E. PER LB. GROWTH FOR GROWN-UP CATTLE (AT LEAST 2 BROAD THICK) IN DIFFERENT CONDITION.

Condition at beginning of period	Condition at end of period (it is presumed that an even alteration of condition has taken place throughout the period)				
	Thin	Thin to normal	Normal	Normal to fat	Fat
Thin ..	2·0	2·2	2·4	2·6	2·8
Thin to normal	2·2	2·4	2·6	2·8	3·0
Normal ..	2·4	2·6	2·8	3·0	3·2
Normal to fat ..	2·6	2·8	3·0	3·2	3·4
Fat ..	2·8	3·0	3·2	3·4	3·6

TABLE VI.

THE DAILY AMOUNT S.E. FOR MILKING COWS OF DIFFERENT WEIGHT.

Lb. milk when the fat content of the milk in per cent is							Maintenance and Production S.E. for milking cows when the weight in lb. is										Lb. milk when the fat content of the milk in per cent is							
P.S.E. for milk	3·0	3·2	3·4	3·6	3·8	4·0	600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500	4·5	5·0	5·5	6·0	6·5	7·0	7·5	P.S.E. for milk
0·28	1·2	1·2	1·1	1·0	1·0	1·0	4·43	4·96	5·36	5·16	6·15	6·53	6·91	7·28	7·63	7·96	1·0	0·9	0·8	0·8	0·7	0·7	0·7	0·28
0·57	2·4	2·3	2·2	2·1	2·1	2·0	4·72	5·25	5·65	6·05	6·44	6·82	7·20	7·57	7·92	8·25	1·9	1·7	1·6	1·5	1·5	1·4	1·3	0·57
0·85	3·5	3·4	3·3	3·2	3·1	3·0	5·00	5·53	5·93	6·33	6·72	7·10	7·48	7·85	8·20	8·53	2·8	2·6	2·4	2·3	2·2	2·1	2·0	0·85
1·14	4·7	4·5	4·4	4·3	4·1	4·0	5·29	5·82	6·22	6·44	7·01	7·39	7·77	8·14	8·49	8·82	3·7	3·5	3·3	3·1	2·9	2·8	2·6	1·14
1·42	5·9	5·7	5·5	5·3	5·2	5·0	5·57	6·10	6·50	6·90	7·29	7·67	8·05	8·42	8·77	9·10	4·7	4·3	4·1	3·8	3·6	3·4	3·3	1·42
1·70	7·1	6·8	6·6	6·4	6·2	6·0	5·85	6·38	6·78	7·18	7·57	7·95	8·33	8·70	9·05	9·38	5·6	5·2	4·9	4·6	4·4	4·1	3·9	1·10
1·99	8·2	8·0	7·7	7·4	7·2	7·0	6·14	6·67	7·07	7·47	7·86	8·24	8·62	8·99	9·34	9·67	6·5	6·1	5·7	5·4	5·1	4·8	4·6	1·99
2·27	9·4	9·1	8·8	8·5	8·2	8·0	6·42	6·95	7·35	7·75	8·14	8·52	8·90	9·27	9·62	9·95	7·4	7·0	6·5	6·2	5·8	5·5	5·2	2·27
2·56	10·6	10·2	9·9	9·6	9·3	9·0	6·71	7·24	7·64	8·04	8·43	8·81	9·19	9·56	9·91	10·24	8·4	7·8	7·3	6·9	6·5	6·2	5·9	2·56
2·84	11·8	11·4	11·0	10·6	10·0	10·0	6·99	7·52	7·92	8·32	8·71	9·09	9·47	9·84	10·19	10·52	9·3	8·7	8·2	7·7	7·3	6·9	6·6	2·84
3·41	14·1	13·6	13·2	12·8	12·4	12·0	7·56	8·09	8·49	8·89	9·28	9·66	10·04	10·41	10·76	11·09	11·2	10·4	9·8	9·2	8·7	8·3	7·9	3·41
3·98	16·5	15·9	15·4	14·9	14·4	14·0	8·13	8·66	9·06	9·46	9·85	10·23	10·61	10·98	11·33	11·66	13·0	12·2	11·4	10·8	10·2	9·7	9·2	3·98
4·54	18·8	18·2	17·6	17·0	16·5	16·0	8·69	9·22	9·62	10·02	10·41	10·79	11·17	11·54	11·89	12·22	14·9	13·9	13·1	12·3	11·6	11·0	10·5	4·54
5·11	21·2	20·5	19·8	19·1	18·6	18·0	9·26	9·79	10·19	10·59	10·98	11·36	11·74	12·11	12·46	12·79	16·7	15·7	14·7	13·8	13·1	12·4	11·8	5·11
5·68	23·5	22·7	22·0	21·3	20·6	20·0	9·83	10·36	10·76	11·16	11·55	11·93	12·31	12·68	13·03	13·36	18·6	17·4	16·3	15·4	14·5	13·8	13·1	5·68
6·25	25·9	25·0	24·2	23·4	22·7	22·0	10·40	10·93	11·33	11·73	12·12	12·50	12·88	13·25	13·60	13·93	20·5	19·1	18·0	16·9	16·0	15·2	14·5	6·25
6·82	28·3	27·2	26·4	25·6	24·8	24·0	10·97	11·50	11·90	12·30	12·69	13·07	13·45	13·82	14·17	14·50	22·3	20·8	19·6	18·4	17·4	16·6	15·8	6·82
7·38	30·6	29·6	28·6	27·6	26·8	26·0	11·53	12·06	12·46	12·86	13·35	13·63	14·01	14·38	14·73	15·06	24·2	22·6	21·3	20·0	18·9	17·9	17·1	7·38
7·95	33·0	31·9	30·8	29·7	28·9	28·0	12·10	12·63	13·03	13·43	13·82	14·20	14·58	14·95	15·30	15·63	26·0	24·4	22·9	21·5	20·4	19·3	18·4	7·95
8·52	35·3	34·1	33·0	31·9	30·9	30·0	12·67	13·20	13·60	14·00	14·39	14·77	15·15	15·52	15·87	16·20	27·9	26·1	24·5	23·1	21·8	20·7	19·7	8·52
9·09	37·7	36·4	35·2	34·0	33·0	32·0	13·24	13·77	14·17	14·57	14·96	15·34	15·72	16·09	16·44	16·77	29·8	27·8	26·2	24·6	23·3	22·1	21·1	9·09
9·66	40·1	38·6	37·4	36·2	35·1	34·0	13·81	14·34	14·74	15·14	15·53	15·91	16·29	16·66	17·01	17·34	31·6	29·5	27·8	26·1	24·7	23·5	22·4	9·66
10·22	42·4	41·0	39·6	38·2	37·1	36·0	14·37	14·90	15·30	15·70	16·09	16·47	16·85	17·22	17·57	17·90	33·5	31·3	29·5	27·7	26·3	24·8	23·7	10·22
10·51	44·7	43·2	41·8	40·3	39·2	38·0	14·66	15·19	15·59	15·99	16·38	16·76	17·14	17·51	17·86	18·19	35·3	33·1	31·1	29·2	27·1	26·2	25·0	10·51
11·36	47·1	45·5	44·0	42·5	41·2	40·0	15·51	16·04	16·44	16·84	17·23	17·61	17·99	18·36	18·71	19·04	37·2	34·8	32·7	30·8	29·1	27·6	26·3	11·36
12·78	53·0	51·2	49·4	47·8	46·4	45·0	16·93	17·46	17·86	18·26	18·65	19·03	19·41	19·78	20·13	20·46	41·8	39·2	36·8	34·6	32·8	31·0	29·6	12·78
14·20	58·8	56·8	55·0	53·2	51·6	50·0	18·35	18·88	19·28	19·68	20·07	20·45	20·83	21·20	21·55	21·88	46·6	43·4	40·8	38·4	36·4	34·4	32·8	14·20
15·62	64·8	62·6	60·4	58·6	56·8	55·0	19·77	20·03	20·43	20·83	21·49	21·87	22·25	22·62	22·97	23·30	51·2	47·8	44·8	42·4	40·0	38·0	36·0	15·62
17·04	70·6	68·2	66·0	63·8	61·8	60·0	21·19	21·72	22·12	22·42	22·91	23·29	23·67	24·04	24·39	24·72	55·8	52·2	49·0	46·2	43·6	41·4	39·4	17·04
18·46	76·4	73·8	70·4	69·2	67·0	65·0	22·61	23·14	23·44	23·88	24·33	24·71	25·09	25·46	25·81	26·14	60·4	56·6	53·0	50·0	47·2	44·8	42·6	18·46

TABLE VII.

S.E. FOR FOETUS GROWTH.

Weight in lb. .. .. .. Breast circumference ..	700 5′ 1″	800 5′ 4″	900 5′ 6½″	1,000 5′ 9″	1,100 5′ 11½″	1,200 6′ 2″	1,300 6′ 4½″	1,400 6′ 6″	1,500 6′ 7¾″	1,600 6′ 9½″
Month in the gestation period	For animals with weight or breast circumference as above could be counted with S.E. as below from the 6th month of gestation. S.E. PER BEAST AND DAY FOR FOETUS GROWTH									
6th	0·30	0·35	0·40	0·45	0·50	0·55	0·60	0·65	0·70	0·75
7th	0·60	0·65	0·75	0·85	0·95	1·00	1·10	1·20	1·30	1·35
8th	1·00	1·15	1·25	1·40	1·55	1·70	1·80	1·95	2·10	2·25
last	1·50	1·70	1·90	2·15	2·35	2·55	2·75	3·00	3·20	3·40

A VETERINARY GLOSSARY IN KISWAHILI, KIKUYU, MASAI, AND NANDI

Compiled by the Department of Veterinary Services, Kenya Colony

BLADDER—

Kibofu (*Swah.*), Thungi (*Kik.*), Olkulet (*Mas.*), Chepkulet ap sogororek (*Nan.*).

BRAIN—

Ubongo (*Swah.*), Tombo (*Kik.*), Oloipirnyiny (*Mas.*), Gundit (*Nan.*).

CHEST—

Kifua (*Swah.*), Githuri (*Kik.*), Olgoo (*Mas.*), Teget (*Nan.*).

DIAPHRAGM—

Wambangoma (*Swah.*), Rabati (*Kik.*), Enaigara (*Mas.*).

EAR—

Sikio (*Swah.*), Gutu (*Kik.*), Engiok (*Mas.*), Itit (*Nan.*).

EYE—

Jicho (*Swah.*), Ritho (*Kik.*), Engongo (*Mas.*), Konda (*Nan.*).

GALL-BLADDER—

Nyongo (*Swah.*), Nyongo (*Kik.*), Olodua (*Mas.*), Kipsegetetiet (*Nan.*).

GLAND, PRECRURAL (LYMPH)—

Tezi la Papa (*Swah.*), Ngai (*Kik.*), Emurte (*Mas.*), N'gulyelet (if healthy), Borochet (if congested and unhealthy) (*Nan.*).

GLAND, PRESCAPULAR (LYMPH)—

Tezi la Bega (*Swah.*), Ngai (*Kik.*), Olngarigari l'empus (*Mas.*), N'gulyelet (if healthy), Borochet (if congested and unhealthy) (*Nan.*).

HEAD—

Kichwa (*Swah.*), Mutwe (*Kik.*), Elokonya (*Mas.*), Medit (*Nan.*).

HEART—

Moyo (*Swah.*), Ngoro (*Kik.*), Oltau (*Mas.*), Mugulelta (*Nan.*).

HIDE—

Ngozi (*Swah.*), Rua (*Kik.*), Olchoni otoiyo (*Mas.*), Muito (*Nan.*).

HORN—

Pembe (*Swah.*), Ruhia (*Kik.*), Emouo (*Mas.*), Guinet (*Nan.*).

INTESTINES, LARGE—

Matumbo mapana (*Swah.*), Mutura (*Kik.*), imindilis (*Mas.*), Kimestowet (*Nan.*).

INTESTINES, SMALL—

Matumbo madogo (*Swah.*), Mara (*Kik.*), Imonyet (*Mas.*), Biut (*Nan.*).

KIDNEY—

Figo (*Swah.*), Higo (*Kik.*), Olairakuji (*Mas.*), Soronyet (*Nan.*).

LEGS, FORE—

Mikono (*Swah.*), Moko; Maguru ma mbere (*Kik.*), Ngejek oronyi (*Mas.*), Kusto (*Nan.*).

LEGS, HIND—

Miguu (*Swah.*), Maguru ma thutha (*Kik.*), Imuroishi (*Mas.*), Chatit (*Nan.*).

LIVER—

Ini (*Swah.*), Ini (*Kik.*), Emoinywa (*Mas.*), Koito (*Nan.*).

LUNGS—

Mapafu (*Swah.*), Mahuri (*Kik.*), Ilkipiu (*Mas.*), Buwaniki (*Nan.*).

MOUTH—

Kinywa; Mdomo (*Swah.*), Kanua (*Kik.*), Engotok (*Mas.*), Gudit (*Nan.*).

NECK—

Shingo (*Swah.*), Ngingo (*Kik.*), Emurt (*Mas.*), Katit (*Nan.*).

NOSTRILS—

Matundu ya pua (*Swah.*), Maiuru (*Kik.*), Ngumeishin (*Mas.*), Serut (*Nan.*).

OMENTUM—

Mafuta ya tumboni (*Swah.*), Nguring e ngoshoge (*Mas.*), Balalyet ap Moiet (*Nan.*).

SKIN—

Ngozi (*Swah.*), Maguguta (*Kik.*), Olchoni oshal (*Mas.*), Muito (*Nan.*).

SPLEEN—

Bandama; Wengu (*Swah.*), Ruariungu (*Kik.*), Endanum (*Mas.*), Nwaget (*Nan.*).

STOMACH—1ST (RUMEN)—

Tumbo la kwanza (*Swah.*), Ihu (*Kik.*), Nganyore (*Mas.*), Moiet (*Nan.*).

STOMACH—2ND (RETICULUM)—

Tumbo la pili (*Swah.*), Muromo wa ihu (*Kik.*), Oloingoingoisho (*Mas.*), Kipkonyandet (*Nan.*).

STOMACH—3RD (OMASUM)—

Tumbo la tatu (*Swah.*), Nguo nyingi (*Kik.*), Embonoka (*Mas.*), Kipsegeryet (*Nan.*).

STOMACH—4TH (ABOMASUM)—

Tumbo la nne (*Swah.*), Ngirima (*Kik.*), Eminyorr (*Mas.*), Kimunyeryet (*Nan.*).

TAIL—

Mkia (*Swah.*), Mutingoe (*Kik.*), Olkedongoe (*Mas.*), Sarunyet (*Nan.*).

THROAT (OESOPHAGUS)—

Umio wa chakula (*Swah.*), Olgos (*Mas.*), Sindo (*Nan.*).

TONGUE—

Ulimi (*Swah.*), Rurimi (*Kik.*), Olngejep (*Mas.*), Ngelyefta (*Nan.*).

UTERUS—

Mji wa mimba (*Swah.*), Nyungu ya mwana (*Kik.*), Enguset (*Mas.*), Ruanda ap moor (*Nan.*).

VAGINA—

Kuma; Uke (*Swah.*), Giciaro (*Kik.*), Engomos (*Mas.*), Letut (*Nan.*).

VULVA—

Midomo ya kuma (*Swah.*), Ngiluai (*Mas.*).

WINDPIPE (TRACHEA)—

Koo la hewa (*Swah.*), Mumero (*Kik.*), Olgos; Oloru (*Mas.*), Chepororet (*Nan.*).

BOOK REVIEW

THE USE OF AERIAL SURVEY IN FORESTRY AND AGRICULTURE, By J. W. B. Sisam. Joint Publication, No. 9, Imperial Agricultural Bureau, Penglais, Aberystwyth, Wales, 1947. Price, 7/6, pp. 49, plus 67 photos.

This booklet gives a concise account of the value of aerial survey in planning land use, and it is clear that the bird's-eye view can be of very great assistance to those who usually have to be content with the limited outlook which is obtained on the ground. As the title indicates, most of the text deals with aerial mapping, its efficiency and cost and the interpretation and application of aerial photograph. A summary is also included of the extent to which aerial survey has been applied to the study of land use and vegetation in different parts of the world, and it is interesting that some valuable pioneer work has been carried out in the British Colonial Empire. Sufficient experience has been obtained in the tropical dependencies to show the immense value of aerial surveys to agriculture, forestry, geology, vegetation studies and land use, and it is clear that the time is ripe for much greater use of aerial maps.

Both vertical and oblique photographs are included, and while verticals are necessary for mapping and for measurement, the interpretation of these requires special training. Obliques can be very instructive for scientific studies, and their use might be greatly extended, since they do not require the highly specialized equipment necessary for aerial mapping. An accurate aerial survey must be carried out on a large scale, but the increasing use of light charter planes in the tropics makes amateur aerial photography a potentially useful scientific weapon with relatively little special equipment. Some of the photographs reproduced in this book were taken with a miniature camera, and it is probable that any good camera, with a long focus lens and special film, would produce sufficiently good aerial photographs to assist investigations in land use and other branches of agricultural science. The "sudden death" disease of clove trees in Zanzibar provides an excellent example of this. From the ground it is extremely difficult to follow the spread of the disease, but from the air the pattern of its progress is so clear that even relatively poor aerial photographs could be used to record its path.

It is noteworthy that infra-red film, used with a minus blue filter, gives very good detail in aerial photographs, and this application of the infra-red emulsion to visible light seems to have great possibilities in the photography of tropical vegetation, where very fine contrast is necessary.

D. W. D.

ESSENTIAL OILS

A very great deal of interest is being evinced throughout East Africa in the subject of essential oils. Perhaps the very high prices which have been obtained during the war years have attracted some, perhaps the idea of producing a high valued crop, the transport of which is relatively low, has attracted others, and perhaps some like the operations involved in the distillation and separation of the oils. Most, however, have the idea firmly fixed in their minds that all they need to do is to obtain cuttings or seeds of an essential oil plant, buy or make a still, and they are on a safe wicket. There are many snags!

The essential oil market is rather peculiar. Users of the oils have evolved formulae for the perfumes or flavours based upon well known oils, and a newcomer has to establish his oil on the market. The first step is to make certain that the variety of the plant he obtains is the same, or very similar to that from which an established oil is produced. This may take some years of experimentation. Having obtained the strain, it is not certain that the soil and climatic conditions of an area will enable the plant to produce the same quality of oil.

Suppose that an attractive oil is produced, the trouble is now to establish it on the market. Prospective growers may think the best way of doing this is to approach a number of agents, say, in London, and ask them to dispose of the oil, but this is the wrong way. Agents are not philanthropists; they are there to make money and should a market be found, will bid against each other so as to secure the commission, with the result that the grower suffers, because the manufacturer naturally pays as little as possible for his raw material. It is necessary for the grower to co-operate with others producing the same type of oil and then for the group to make arrangements with a reputable essential oil broker in London for the sale of the oil, assuring him that he will have the sole agency for that oil. By this means, the growers ensure that the broker will be prepared to take trouble over the establishment of the oil on the market. It is in the securing of co-operation that one of the greatest difficulties lies.

The essential oil market is comparatively restricted. Granted there are always demands for certain oils, but, by and large, the demand is restricted. During the war, supplies of essential oils were largely cut off and the demand greatly exceeded the supply, so prices rose enormously. For example, the Seychelles, at one time, was practically the sole source of Patchouli Oil, and the growers secured prices in India of Sh. 300 and over, per lb. of oil. Supplies of Malayan and Java oils have now come on the market, with the result that the price of the Seychelles oil is dropping fast and to-day is quoted at Sh. 55 per lb. When prices drop there is a tendency for the grower to increase his acreage under the plant and so increase his output; nearly every grower does this, with the result that the market is overstocked and down comes the price. The graphs of the prices of most essential oils are worse than the temperature chart of a fever patient. Thus, it is difficult to make any safe estimate of the financial return from essential oil growing.

There is one big advantage in essential oils for farmers who are a long way from railhead. The cost of transport, relative to the value of the product, is low. It costs as much to transport by lorry 1 lb. of maize worth 10 cents as it does to transport 1 lb. of Geranium Oil worth Sh. 20.

If one is really interested in the operations involved and is prepared to accept the fact that the growing of essential oils is, in the long run, no more profitable than normal farming and is a great deal more "chancy", then it is worth while for one's own enjoyment of life to produce essential oils. On the other hand, if one looks upon it as a means of getting rich quick, certain disappointment lies ahead.

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MAHOGANY REGENERATION IN THE BUDONGO FOREST, UGANDA

A note appeared in the 1945 News Bulletin of Empire Forest Departments giving an outline of the methods used to restock the exploited parts of the Budongo Forest with *Khaya anthotheca*. During 1946 planting technique has gone a step further and will probably be of interest to other East African foresters.

In the past restocking has been done by the line-group method. In this, lines were cut on a compass bearing (P.N.) at intervals of 150 ft. and groups of three trees were planted 80 ft. apart in the line. Inter-line groups were also planted. These were situated 75 ft., at a right-angle, from the cut line and were spaced 150 ft. apart. Spacing of trees in each group was about 10 ft. This method of planting was chiefly used as a deterrent against animal damage.

Through planting trees in the forest growth on the side of cut lines and employing a game scout to shoot animals which ventured near a planted area, it has been found during the past two years that animal damage has been negligible. It was decided, therefore, to stock the 1946 area, some 1,350 acres, by cutting lines at intervals of 75 ft. and to space the plants in the lines 25 ft. apart. Slightly more work is entailed by this method but supervision is easier. At present *Khaya anthotheca* is the chief species planted and fills each alternate line, while other lines are planted with *Entandrophragma utile, E. angolense, Chlorophora excelsa, Lovoa brownii, Mildbraediodendron excelsum* and *Albizzia coriaria*.

All species are planted as striplings or stocks and formerly roots were pruned so that only the carrot remained. In the 1946 planting as little root pruning as possible was done, i.e. only sufficient was cut off to allow the root to be inserted in a pit two feet by one foot. Ramming proves slightly more difficult through leaving these side and fibrous roots, but by making the pit larger at the top to allow ramming at the base of the carrot and, secondly, by piling soil some 12 in. up the stem of the plant and ramming this until it worked its way through the network of roots the trees can be well firmed. It is thought that these fibrous roots adapt themselves to the soil a few days after the trees are planted, since some four weeks after planting, the bulk of the trees start to make new growth. When only the carrot remains many trees do not start to grow until six or twelve months have elapsed and also many have insufficient root system to sustain them through the dry period from January to April. All planting in 1946 was finished by mid-July and a few trees lifted in October showed good root development and almost complete occlusion at the base of the carrot. Another improvement in the 1946 planting was that no tree remained unplanted for more than 24 hours after lifting.

At the time of writing (October, 1946), the whole area is a pleasing sight and every species planted has made good growth. For the first time *Entandrophragma utile* shows promise but final results will not be known until the coming dry season has passed.

In all planting to date, growth of trees on the forest edge has been much more vigorous than inside the forest and it has become very apparent that *Khaya* will not tolerate shade. A start has now been made to lighten the canopy throughout the 1944 and 1945 area. This is done by girdling large trees and felling smaller ones. In the first stages it was difficult to teach people doing such work which trees to cut and which to leave but after a month the porters did the work with little supervision. Many trees after being opened up make new growth within two or three weeks and from showings so far it appears essential that all dense overhead shade should be removed during the first or second year of planting.

A trial plot of some eight acres of compensatory planting was done over a cleared area in the forest. Spacing of trees in this was fifteen feet by fifteen feet. Two species were planted, *Khaya anthotheca* and *Entandrophragma utile*. Both were two year plants; the former being up to ten feet in height and the latter three feet six inches. The mixture consisted of alternate line planting. All the *Khaya* have established themselves well but a few deaths have been seen amongst the *Entandrophragma*. This type of planting allows easy oversight and a watchful eye can be kept at all times over the planted area. Apparent drawbacks so far are the heavy creeper growth which has to be cut back at short intervals, and damage by animals.

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8th September, 1947.

MOWING AND ITS EFFECT ON LAWNS

Mowing is an essential operation in the upkeep of lawns in order to remove excess growth of grass and maintain the turf in a fine, level condition. That it is also one of the most important operations in lawn maintenance will be evident when it is realized that throughout a period of approximately thirty weeks in the year lawn turf is mown twice or thrice weekly and very close to the ground at that.

Obviously, the actual cutting of the grass, combined with the removal, during the greater part of this period, of the clippings, is bound to have a profound effect on the turf itself. Trials and observations made over many years confirm this view and show unmistakably that no other single factor influences the condition and appearance of fine turf so much as mowing. Vigour of growth, density of the turf, weed invasion and root growth are all very much affected by mowing, and as these really decide whether a lawn is to be good, bad or indifferent, a knowledge of what is involved should be of use to the gardener.

One of the first points to be considered is the effect of continual mowing on the reserves of plant food in the soil. Clearly, one cannot constantly remove grass clippings from a lawn without taking away certain plant nutrients, but in this connexion there has been a good deal of loose thinking. It has been assumed that the more frequently a lawn is mown, the greater is the drain of plant food from the soil. Analysis, however, shows that this is not so, and the following figures are highly interesting in this connexion. They show the relative amounts of plant food removed from turf under two systems of mowing.

	Mown weekly.	*Mown thrice weekly.*
Nitrogen	91.58	80.95
Phosphoric acid ..	19.83	17.74
Potash	57.65	54.20

These figures indicate that if one mows a lawn very frequently, the loss of plant food is not so great as in the case of lawns mown less frequently. The reason for this, briefly, is that when grass is repeatedly cut it falls off in yield and accordingly takes less out of the soil. It follows, therefore, that the deterioration which often occurs in lawn turf constantly mown may not necessarily be due to impoverishment of the soil—the explanation most commonly put forward. The effect of the actual cutting on the various plants comprising the turf is probably much more important in this connexion.

It is obvious that those plants which are erect in habit of growth, such as the fine Fescues, are severely punished each time mowing takes place, and as a result of this they tend to become weak and sparse. However, those plants which lie close pressed to the ground or adopt a creeping habit are never seriously punished by the rotary mower unless the machine is set very low. As a direct consequence of this they tend to flourish and spread. Over a period of years, lawn turf which is constantly mown changes in character quite decisively. White Clover, Creeping Buttercup, Pearlwort, Yarrow, Starweed and many other obnoxious turf weeds are likely to spread, while the fine lawn grasses decrease in amount. Add to this the readily observed fact that many of these weeds, apart from escaping injury by mowing, can produce and ripen seeds beneath the level of mowing, and the deterioration of much fine turf can readily be understood.

The practical implications of these findings are of the utmost importance in lawn and turf upkeep. In the first place steps should be taken to overcome the disadvantages of mowing by systematic raking or brushing prior to cutting the lawn. It has been established that such treatment, carried out regularly, controls the spread of several weeds most effectively since it enables creeping stems and prostrate growth to be lifted and cut by the mower. The use of mechanical rakes and wide drag brushes greatly expedites this work and permits it being adopted each time before mowing during the summer months. To offset the punishment inflicted on the fine turf grasses by mowing, cutting should be carried out at very close intervals, but not too keenly. In this way the grass receives very little setback and cutting amounts to nothing more than "topping". Daily mowing, if it were practicable, would be the very best method of maintaining turf in a vigorous, dense condition.

Naturally, the loss of plant food, although much less than normally assumed, must be made good by occasional light fertilizer dressings. In this connexion it is worth remembering that, under continuous mowing of turf, the loss of nitrogen is greatest of all, with potash second and phosphate third. The replacement of nitrogen is usually made by applying either quick-acting fertilizers such as sulphate of ammonia, or slower acting materials such as dried blood. The rather heavy drain on potash calls for the use of mixed fertilizers containing a fair proportion of potash or the application of wood ash—a material much favoured by gardeners, and rightly so. Phosphate, although removed in least amount, is valuable for root growth and should always be included in a well-balanced lawn dressing.

I. G. LEWIS, N.D.A.

[*Gardeners Chronicle*, July 19th, 1947, p. 20.]

SPECIES OF SAINTPAULIA

Regular visitors to the Orchid houses at Kew may have noticed that in recent years the usual edging of the East African Violet, *Saintpaulia ionantha*, has been varied by the introduction of two other species of the same genus, *S. tongwensis* and *S. orbicularis*. Any search for information about these species will, I regret to state, have been in vain, as their description was not completed in time for publication before the disruption of Kew publications owing to the war. The present article gives some general information about the species of this genus and includes technical diagnoses of those not hitherto described; a more detailed account will be published later.

Our increased knowledge of *Saintpaulia*, a genus of *Gesneriaceæ* restricted to East Africa, is largely due to the enthusiasm of Mr. and Mrs. R. E. Moreau, who made a special study of this genus in the field, and who are responsible for the introduction of the new species into cultivation.

The original species of the genus *S. ionantha*, H. Wendland, was described from cultivated plants grown from seeds collected in East Africa. When preparing an article for Curtis's *Botanical Magazine* (tab. 7408) Sir Joseph Hooker wrote to the introducer's father, Baron Hofmarschal Saint Paul, for particulars of the plant. In reply, Baron Saint Paul said that his son had found the plant in two different localities: "One about one hour from Tanga in wooded places on limestone rocks, in the fissures thereof as well as in rich soil, with plenty of vegetable matter. This place is not more than 10 to 50 meters above the sea level. The second place is in the primeval forest of Usambara, likewise in shady situations, but on granite rocks about 800 m. above the sea".

Shortly afterwards E. Benary, the Erfurt nurseryman who had bought the stock of *Saintpaulia*, sent fruits to Dr. Maxwell Masters at Kew. Benary wrote: "It seems to be quite a peculiarity of this plant to produce capsules of two different shapes, as you will remark, one long and the other round-shaped," and added that the different types of capsule were never found on the same plant.

These extracts suggest that the original introduction of *Saintpaulia* included two closely allied species. Wendland's description of *S. ionantha* is based on only one of these and it is clear from cultivated specimens that the short fruits sent by Benary to Masters are true *S. ionantha*. The only evidence hitherto available as to the native locality of this plant was indirect; a herbarium specimen from inland in Usambara (Buchwald 149) having proved distinct from *S. ionantha*, it was inferred that the true species came from the coastal Tanga area. The very interesting series of specimens of *Saintpaulia* collected by Mrs. Moreau not only justifies her opinion that the coastal species are distinct from those found in the mountains of Usambara, but proves that the true *S. ionantha*, as described and illustrated by H. Wendland, is the plant found in the neighbourhood of Tanga. Wendland's description of *S. ionantha* needs no emendation, but we can now add to our recorded knowledge of the species two precise localities from which herbarium specimens have been examined and confirmed:—

Tanganyika Territory.—Amboni, near Tanga, growing on crystalline gneiss about 5 miles inland, sea level; Mrs. R. E. Moreau, No. 3.

Mkalamusi Forest, Tanga, growing on limestone in coastal evergreen bush; Mrs R. E. Moreau, No. 5.

When writing the account of *Saintpaulia* for the *Flora of Tropical Africa*, C. B. Clarke distinguished the inland and coastal plants which had hitherto been included under *S. ionantha*, but unfortunately he accepted the herbarium specimen from Usambara already mentioned (Buchwald 149) as being that species and re-described true *S. ionantha* as *S. kewensis*. Somehow, in succeeding years, the application of these two names became reversed, for the plant long grown at Kew as *S. ionantha* is correctly named and that grown as *S. kewensis* is the same species as *Buchwald* 149 and also as specimens cultivated at Amani by Mrs. Moreau. This latter plant is thus still without a name; it is most easily distinguished from *S. ionantha* by the dual indumentum of long and short hairs which clothes the leaves contrasting with the hairs of uniform length found in *S. ionantha*; for this reason I designate the plant *S. diplotricha*. It is this species which provided the long-fruited plants mentioned by Benary in his original stock of *Saintpaulia*.

Another species is also closely allied to *S. ionantha*, but has longer, more elliptic leaves with a subacute tip, it also has longer fruits, which are densely hairy. This has been grown at Kew for several years past and is the plant I have named *S. tongwensis*.

A third species is characterized by its orbicular leaves, which are cordate at the base, and by the flowers being smaller, more numerous and of a paler colour. This is my *S. orbicularis*.

All these four species are typically rosette plants, but there is another species, *S. Grotei*, Engl., which has a creeping stem rooting at the nodes. Although cultivated at Kew for a short time it has now been lost and we must await its reintroduction.

Technical diagnoses of the new species, of which the type specimens are in the Kew herbarium, are appended*.

I exclude from the genus *Saintpaulia S. alba*, E. A. Bruce (in *Kew Bull.*, 1933, p.475), which on account of its almost campanulate corolla, without the characteristic flat limb of *Saintpaulia*, is better transferred to the closely allied genus *Linnæopsis* and becomes, therefore, *Linnæopsis alba* (E. A. Bruce), B. L. Burtt, comb. nov. B. L. Burtt, The Herbarium, Kew.

* *Saintpaulia diplotricha*, B. L. Burtt, sp. nov., a *S. ionantha*, H. Wendl., *foliis pilis brevibus dense obsitis et insuper aliis longioribus præditis, fructibus cylindricis* 1–1.3 cm. *longis villosis leviter falcatis recedit.*

Tanganyika Territory. Usambara, 1,000 m., 26th Nov., 1895, Buchwald 149.

Saintpaulia orbicularis, B. L. Burtt, sp. nov., *foliis orbicularibus basi cordatis inflorescentiis plurifloris, floribus pallidioribus distinguitur.*

Tanganyika Territory. Sakarre, Ambangulu, on a wet rock (gneiss) beside a waterfall, 1,200 m.; upper side of corolla almost pure white, but with a deep lavender ring round the anther cells, underside of lobes white with light crimson middle vein and tips washed with same colour; 4 Aug., 1938, Mrs. R. E. Moreau No. 2.

Saintpaulia tongwensis, B. L. Burtt, sp. nov., *S. ionanthæ*, H. Wendland, *arcte affinis, foliis ellipticis subacutis fructibus longioribus densissime pilosis recedit.*

Tanganyika Territory. Mt. Tongwe, near Pangani; restricted to a ledge of gneiss 50 yards long near the summit, 2,300–2,400 m., H. R. Herring (comm. Mrs. R. E. Moreau No. 4).

[*Gardeners Chronicle*, July 19th, 1942, p. 22.]